425 Operator's Manual OSCILLOSCOPE

DUMONT

425

ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, NEW JERSEY, U. S. A.

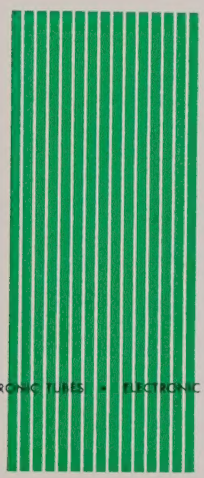
TYPE

425 OSCILLOSCOPE

Operator's Manual

DU MONT

Serial No. _____



ELECTRONIC TUBES • ELECTRONIC INSTRUMENTATION • INDUSTRIAL TELEVISION • MILITARY ELECTRONICS • AUTOMOTIVE TEST EQUIPMENT • TWO WAY RADIO

ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, NEW JERSEY, U. S. A.

Copyright 1960
ALLEN B. DU MONT LABORATORIES, INC.
INDUSTRIAL ELECTRONICS DIVISION
Clifton, N. J.
U. S. A.

Part Number 6703 8291

PRINTED IN U.S.A.

Printing Produced by
THE GEORGE R. EPPLE CO.
Somerville, N. J.

TABLE OF CONTENTS

SECTION 1. TECHNICAL SUMMARY

Paragraph		*Page*
1-1	Introduction	1-1
1-2	Features	1-1

SECTION 2. OPERATING INSTRUCTIONS

2-1	Cooling	2-1
2-2	Time-Delay DC Power Relay	2-1
2-3	Precaution Against Screen Burning	2-1
2-4	Illuminated Scale	2-1
2-5	First-Time Operation	2-2
2-6	Summary of Automatic and AC Triggering Modes	2-11
2-7	DC Triggering Mode	2-11
2-8	Single Sweep	2-13
2-9	Displaying a Signal by Means of the Du Mont Type 4203 Delaying Sweep Plug-in Unit	2-13
2-10	Summary of Front-Panel Facilities	2-20
2-11	Triggering Hints	2-25

SECTION 3. APPLICATIONS

3-1	Vertical Deflection Channel	3-1
3-2	Reduction of Jitter	3-2
3-3	Voltage Measurements	3-3
3-4	How to Use the Digital Contact Closures for External Read-Out Indication	3-6
3-5	How to Use the External Read-Out Analog Outputs	3-6
3-6	How to Command External Equipment to Record	3-6
3-7	Making Rise-Time Measurements	3-7
3-8	Making Fall-Time Measurements	3-8
3-9	Time Measurements	3-9
3-10	Phase Angle Measurements	3-11
3-11	Accessory Functions	3-12

Figure 1-1. Du Mont Type 425 Oscilloscope

SECTION 1
TECHNICAL SUMMARY

1-1. INTRODUCTION

This *Operating Manual* includes information on Specifications, Operating Instructions, and Applications for the Du Mont Type 420-Series Oscilloscopes. The *Maintenance Manual* for these series is a separate book and it contains Service Information, Procedures for Internal Adjustments, Schematics, and Parts List. *The Operating and Maintenance* Instructions for the Plug-in Units will be found in a single manual for the respective unit.

1-2. FEATURES

The Du Mont Type 420-Series Oscilloscopes are high-speed laboratory instruments. Among their outstanding features are two Plug-in Units which permit highly versatile operation in the Y amplifier, X Amplifier, in the Delaying Sweep, and in the systems accessory fields. The Cathode-ray Tube has an overall accelerating potential of 12,000 volts which when linked to the fast rise time of the Y Amplifier, and with the wide range of sweep rates, opens the way to faster and easier analysis of fast-rising waveforms. The Du Mont Type 425 Oscilloscope employs a unique Read-Out system which may be considered as an easy-to-use precise analog to digital converter usable from dc to well over 50 megacycles for rise times to 10 millimicroseconds (10 nsec) in the Y Channel and differential time measurements to 1 millimicrosecond (1 nsec) in the X Channel.

Accurately calibrated sweep speeds and vertical deflection sensitivities permit quantitative time and amplitude measurements to be made. A precise Delaying Sweep makes possible the selection and detailed observation of minute portions of the input waveform. Table 1-1 lists the electrical and physical characteristics of this instrument which follows:

section 1
technical summary

TABLE 1-1
TECHNICAL SUMMARY
DU MONT TYPE 420-SERIES OSCILLOSCOPES

VERTICAL-DEFLECTION SYSTEM

MAIN FRAME AMPLIFIER

Input Coupling	DC coupled; balanced
Rise Time	0.009 microsecond (9 nsec)
Y Sensitivity	0.125 volt/centimeter
Delay Line	Multi-sectioned balanced network
Signal Delay	200 millimicroseconds (200 nsec)
Y Linear Deflection	5 centimeters

RESPONSE WITH TYPE 4202 Y DUAL-TRACE PLUG-IN

Deflection Factor	50 millivolts/centimeter
Rise Time	11 millimicroseconds (11 nsec); (10 nsec with Type 4201 plug-in)
Frequency Response	
Direct Coupled	DC to 33 megacycles, down 3 db ± ½ db (DC to 36 mc, ± ½ db; Type 4201)
Capacitively Coupled	From 2 cycles to 33 megacycles, down 3 db, ± ½ db at 33 megacycles; 6 db at approximately 45 megacycles
Input Attenuation	Provided by a frequency compensated attenuator with steps from 0.05 volt/cm to 20 volts/cm, accurate to within 2% when set on any one step; OFF and CAL positions are provided
Maximum Allowable Combined DC and AC Peak Voltage Input	600 volts
Input Impedance	1 megohm, 23 pf (μμf)
Input Impedance Using 10 to 1 Attenuator Probe	10 megohms, 10 pf (μμf)
Y Read Out	Available with Channel A input

HORIZONTAL-DEFLECTION SYSTEM

CALIBRATED MAIN SWEEP

Calibrated Sweep Rates	From 0.05 microsecond/cm to 2 seconds/cm in 24 steps
Accuracy	Adjustable to better than ½% on the 0.05 microsecond/cm range and on one other selected range; all other ranges within 3%
Uncalibrated Sweep Rates	Continuously variable, uncalibrated between ranges and to 6 seconds/cm (1 minute full scale)
Expander	5 times expansion about the center of the screen. Extends fastest sweep rate to 0.01 microsecond/cm (10 nsec/cm)
Expanded Sweep Rate Accuracy	Normally within 2%; always within 5%

RESPONSE WITH TYPE 4203 CALIBRATED DELAYING SWEEP PLUG-IN

Delay Time	Continuously variable from 0.5 microsecond/cm to 10 seconds/cm
Time Jitter	Untriggered: Less than 1 part in 30,000 with voltage stabilized power line Less than 1 part in 22,000 with normal power line Triggered: Jitter free
Range Accuracy	Normally within 2%; always within 3%
Reset Accuracy	Better than 1 part in 750

TABLE 1-1. TECHNICAL SUMMARY (Continued)

CALIBRATED DELAYING SWEEP

Delaying Sweep Rates	18 calibrated sweep rates from 1 microsecond/cm to 1 second/cm
Accuracy	Adjustable to better than ½% on the 1 microsecond/cm range and on one other selected range; all other ranges normally within 2%; always within 3%
Delaying Sweep Length	Continuously variable from less than 4 centimeters to more than 10 centimeters
Unblanking	DC coupled and discretely variable with respect to the Main Sweep
Trigger Rate Source	Continuously variable from 5 cycles to 60 Kc using the free-running Delaying Sweep as the generator

OUTPUT WAVEFORMS

Gate	Positive gate of same duration as the Delaying Sweep; 20 volts
Saw	Delaying Sweep sawtooth waveform; 60 volts
Del Trig	Delayed Trigger pulse from the Main or Delaying Sweep circuit; 5 volts

TRIGGER SHAPER

Ext Sig	1 volt input; trigger shaper, 30 cycles to 1 megacycle. Shaped output from Del Trig front-panel connector

READ-OUT SYSTEM (TYPE 425 OSCILLOSCOPE ONLY)

Internal Read Out	A two-dot orthogonal pattern calibration system is provided for both horizontal and vertical Read Out. A Y Polarity reversal switch is provided. A 3-digit decimal switch is provided in the X and Y axes. A fourth digit interpolating vernier is also provided in the X axis.
Accuracy	The Read Out system has a normalized accuracy of ½%. The absolute accuracy is within 3%. The calibration may be monitored and adjusted to within ½% of full scale at the 110-volt supply test jack
10-90% Alignment	A calibrated 10-90% reading feature is provided for rise-time or fall-time measurements
External Digital Read Out	External contact closures coded in a ten-lines-per-digit system are available along with decimal point and multiplier information. Each axis of external Read-Out information has its own common ground which is kept separate from the chassis ground
Analog Outputs	Analog outputs proportional to full scale for the X and Y axes are available. Output is 99.9 millivolts into an impedance of 100K ohms. Normally 2%; always within 5%

CATHODE-RAY TUBE

Type	Du Mont Type K1736 metalized; P1, P2, P7, and P11 phosphors optional
Over-all Accelerating Potential	12,000 volts
Deflection Factor; Direct Connection	
Vertical	6.5 volts/cm maximum
Horizontal	23.6 volts/cm maximum

VOLTAGE AND TIME CALIBRATOR

Waveshape and Frequency	Trapezoidal waveform at power-line frequency. This waveform may be used to calibrate the time axis wherever the power-line frequency is a controlled standard.
Amplitude	CAL 2V available for probe calibration. Each preamplifier attenuator is provided with a calibrated position permitting 4-centimeter calibration of the amplifier system regardless of attenuator accuracy.
Accuracy	Normally 1%; always within 2%

TABLE 1-1. TECHNICAL SUMMARY (Continued)

INDICATOR LAMPS

Beam Indicators	Beam position indicators show direction of beam when it is off the screen
Sweep Ready	Sweep Ready lamp indicates when the Main Sweep is armed
Sync Ready	Sync Ready lamp indicates when the trigger circuits are ready to accept signals. An indication of the most sensitive sync level is obtained when the lamp is "just on."
X1	X1 lamp indicates normal sweep (times 1 expansion)
Cal	Vernier gain lamp on Y preamplifier indicates the calibrated volts/cm position. Lamp extinguishes when amplifier is uncalibrated
Main Sweep Dial	Main Sweep dial lamp extinguishes when the sweep is uncalibrated
Read Out	Vertical and horizontal Read-Out lamps indicate multipliers, polarity, and decimal-point insertion. Lamps extinguish when Read Out is not in use or system is uncalibrated

OTHER CHARACTERISTICS

PRESET POSITIONS

Stability	Preset position provides triggered sweep operation suitable for most triggering applications
Trigger Level	Preset position provides fixed optimized sensitivity
Armed	Single-shot operation of the Main Sweep, either manual or remote reset, are provided

AUTO SYNC

Slow	50 cycles
Fast	900 cycles yields a bright base line

POWER SUPPLY

POWER REQUIREMENTS

Line Voltage	From 103.5 to 127.5 volts or from 207 to 255 volts at 60-cycle line; 105 to 125 volts or from 210 to 250 volts at 50-cycle line
Power	1020 watts average; 1250 volt-amperes at 115-volt, 60-cycle line
Line Frequency	Operation from 48 through 450 cycles with optional direct-current fan motor
Fuses	115-volt operation, 8 and 6.25 amperes; 230-volt operation, 4 and 3 amperes
Ventilation	Forced air, filtered; 60-cycle fan motor may be used at 50 cycles if ambient air intake is below 35° C
DC Power Supplies	Electronically regulated

ACCESSORIES

Accessories Include:

2	10 to 1 Attenuator Probes; 10 μμf (10 pf), 10 megohms
1	Light Filter
1	Maintenance Manual
1	Operator's Manual
1	3-prong to 2-prong adapter plug

PHYSICAL CHARACTERISTICS
(Bench Model)

Height	16½ inches	(41.91 cm)
Width	13½ inches	(34.29 cm)
Depth	27 inches	(68.58 cm)
Net Weight	125 pounds	(56.699 kg)
Shipping Weight	175 pounds	(79.378 kg)

SECTION II
OPERATION

2-1. COOLING

The Du Mont Type 420 Series Oscilloscopes are cooled by filtered, forced-air ventilation. These instruments must therefore be placed so that the air intakes and exhaust are not blocked and the filters must be sufficiently clean to permit adequate air circulation. Should the interior temperature exceed the safety limit, a thermal cutout switch will disconnect power and keep it disconnected until the temperature drops to a safe value. This thermal cutout switch does not affect the fan, thereby minimizing the cooling period.

2-2. TIME-DELAY DC POWER RELAY

A time-delay relay defers application of the rectified dc to the circuits sufficiently long enough for all heaters to reach normal operating temperature. This relay is interlocked with the Plug-in Units and recycles whenever these Plug-ins are interchanged. The time delay is about 45 seconds. If the dc power is switched off momentarily, the time-delay relay will delay reapplication of the dc power. This time-delay relay also removes the switch limiting resistor which protected the heaters during warm-up surge.

2-3. PRECAUTION AGAINST SCREEN BURNING

The Du Mont Type K1736 Cathode-ray Tube in this instrument has a total accelerating voltage of 12,000 volts.

A sharply focused spot of high intensity and small area should not be permitted to remain stationary on the screen for any length of time. Under such conditions, the entire beam energy is concentrated over a small area, thus subjecting the screen material to burning and discoloration. This condition is most likely to exist when in the X-Amplifier mode of operation. A front panel screwdriver control, INTENSITY LIMIT, is available on all X-Amplifier Plug-in Units. The panel intensity control does not permit screen spotting when the time base is at rest, thereby incorporating a safety feature preventing screen damage.

2-4. ILLUMINATED SCALE

The adjustable scale lighting control labeled SCALE may be adjusted to suit the lighting condi-

tions of the room or the f/number on the oscilloscope camera. The colored filter supplied is tinted to provide the maximum trace contrast in the presence of room light. This colored filter should be mounted next to the cathode-ray tube so it does not block light from the calibrated scale. The filter should be removed when photographing the display.

The scale is accurately scribed in centimeters. These scale markings and the calibrated fixed vertical attenuator markings and sweep rates, can be used to convert deflection in centimeters into volts and seconds. Vertical sensitivities are calibrated in volts per centimeter and sweep rates are calibrated in seconds per centimeter, which, multiplied by centimeters of deflection give voltages and seconds. The scale may be omitted when the Read-out presentation is used for display calibration.

2-5. FIRST-TIME OPERATION

a. Instructions

We know that you are anxious to get acquainted with your new instrument. To aid you in this endeavor, you may set up the instrument using the built-in calibrator signal to demonstrate the effects of the various controls on the display. In the instructions which follow, words in capital letters within the text indicate front panel controls, connectors, or settings. A brief description of the front panel controls and connectors is given in a Table at the end of this section.

b. Initial Control Setting

With the Du Mont Type 4202 Y Dual Trace Amplifier and the Type 4203 Delaying Sweep Plug-in Units securely in place, plug the power cord into the proper power source. Set the controls as indicated in Table 2-1.

The operator is advised to follow the specific instructions and sequence of operation as outlined in this section.

TABLE 2-1

PRELIMINARY CONTROL SETTING

CONTROL	SETTING
MAIN FRAME	
EXPAND	X1
DISPLAY LOGIC	MAIN SWP
SWEEP RATE	1 MS/CM
VERNIER	Pushed in
TRIGGER SOURCE	+LINE
TRIG LEVEL	PRESET
TRIGGER MODE	AUTO SLOW
STABILITY (TRIG/REC)*	PRESET
SWITCH MODE	ALTERNATE (out)
POLARITY	+
Y Read Out	000
X Read Out	1.00
INTENSITY, FOCUS, ASTIG, INDEX & PATTERN POSITIONING	Centered
DELAYING SWEEP PLUG-IN	
DELAY MULTIPLIER	3.00
PICK-OFF SOURCE	DEL SWP
SWEEP RATE	5 MS/CM
TRIGGER SOURCE	+LINE
TRIG LEVEL	PRESET
TRIGGER MODE	AC
STABILITY (TRIG/REC)*	PRESET
LENGTH	Fully cw
Y DUAL TRACE PLUG-IN (Channel A)	
VERNIER	Pushed in
VOLTS/CM	CAL
POLARITY	NORMAL
READ OUT	NORMAL
INPUT SELECTOR	A
AC/DC	AC
POSITION	Centered

*The STABILITY (TRIG/REC) control will subsequently be referred to as STABILITY.

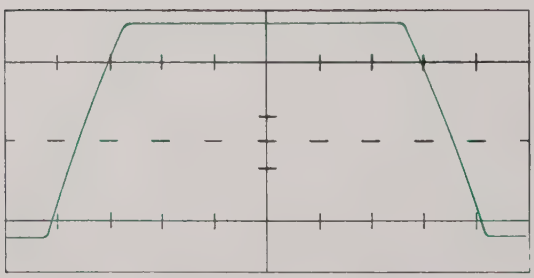


Figure 2-1. Calibrator Waveform Display with the Display Logic Switch Set to Main SWP

c. Effect of the Display Logic Switch

Turn on the power. Forty-five seconds after the power is applied, a pattern as indicated in Figure 2-1 should appear on screen when the DISPLAY LOGIC switch is set to MAIN SWP. Adjust the PATTERN POSITIONING to center the display and adjust the FOCUS and ASTIG controls for the sharpest trace.

Turn the DISPLAY LOGIC switch to the DELAYING SWP position. The pattern indicated in Figure 2-2 should appear on the screen. If the INTENSITY has been properly adjusted, that portion of the waveform between 3 and 5 centimeters should be brighter than the remaining display.

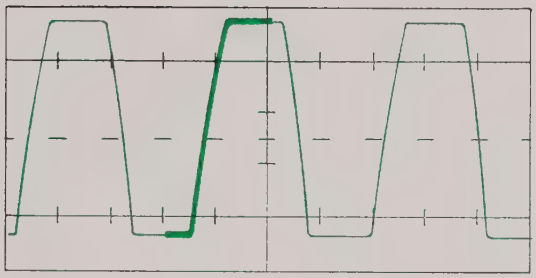


Figure 2-2. Calibrator Waveform Display with the Display Logic Switch Set to Delaying SWP and Pickoff Source Switch Set to Del SWP

Turn the DISPLAY LOGIC switch to MAIN SWP AND DELAYING SWP position. Pull out the Channel A VERNIER control on the Y Plug-in and adjust for two centimeters of vertical deflection.

Adjust SWEEP SEPARATE until a pattern similar to that of Figure 2-3 appears on screen. The SWITCH MODE control may be pushed in to the CHOPped position to eliminate flicker.

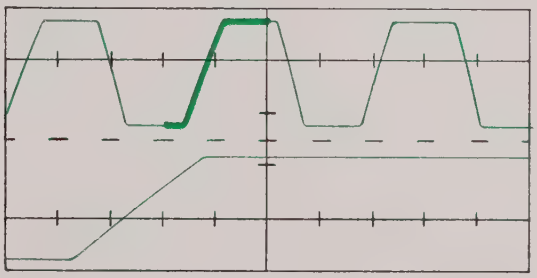


Figure 2-3. Calibrator Waveform Display with the Display Logic Switch Set to Main SWP and Delaying SWP

Turn the DISPLAY LOGIC switch to the R. O. position, then, with the INDEX POSITIONING lever control, position the dots to simulate Figure 2-4.

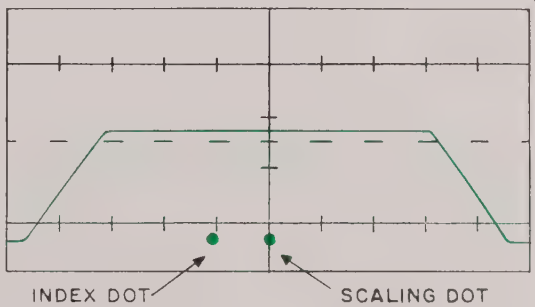


Figure 2-4. Calibrator Waveform Display with the Display Logic Switch Set to R.O.

Push in the Channel A VERNIER control on the Y Plug-in. Position the left hand thumb wheel of the Y Read-Out switch to 1.00 and note that the scaling dot moves up two centimeters. See Figure 2-5a. Return the Y Read-Out switch to 000.

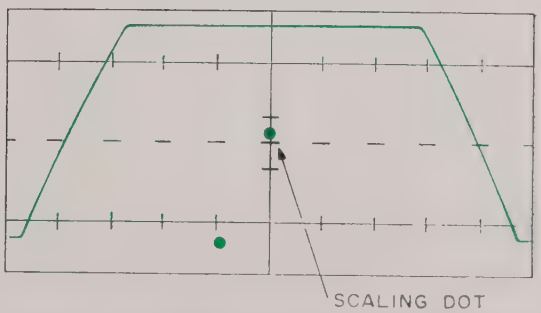


Figure 2-5a. Effect of the Y Read-Out Switch on the Scaling Dot

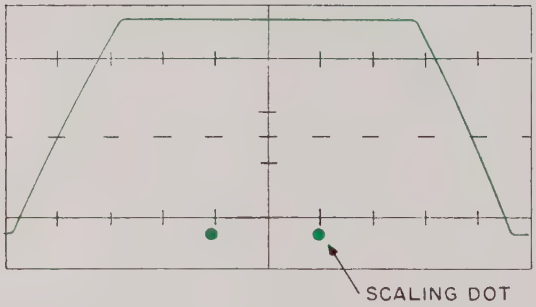


Figure 2-5b. Effect of the X Read-Out Switch on the Scaling Dot

Position the left thumb wheel of the X Read-Out switch to 2.00 and note that the scaling dot now moves to the right one centimeter. See Figure 2-5b. Return the X Read-Out switch to 1.00.

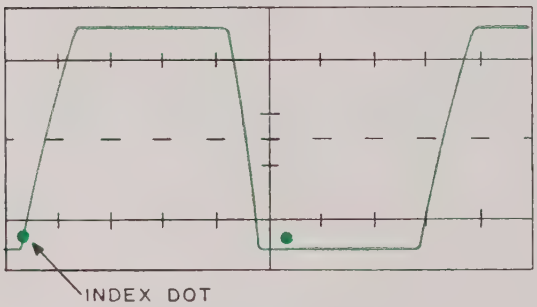


Figure 2-6a. Index Dot Superimposed on the Left Leading Edge of the Waveform

Set the Main SWEEP RATE dial to 2 MS. Adjust the INDEX POSITIONING lever control until the index dot is superimposed on the left leading edge of the waveform as shown in Figure 2-6a.

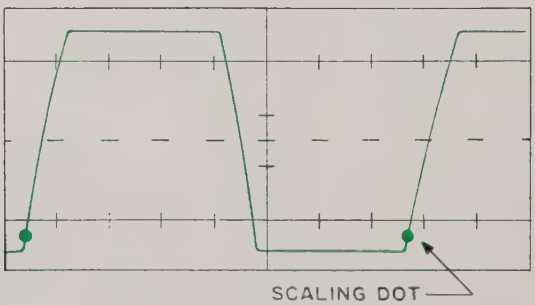


Figure 2-6b. Scaling Dot Superimposed on the Right Leading Edge of the Waveform

Next, adjust the Horizontal Read-Out thumb switches until the scaling dot has moved over to the right and is superimposed on the waveform as indicated in Figure 2-6b.

When this instrument is used on a 60-cycle line, the horizontal Read-Out controls should read between 16.4 and 17 milliseconds. (1/60 cycle = 16.7 ms)

d. Triggering in the Automatic Mode

The calibrator waveform display you have been looking at is a periodic signal. In other words, the waveform repeats itself at regular intervals. This display is formed by the repetitive sweep of the spot across the cathode-ray tube screen.

If the sweep is allowed to occur at random or at a rate unrelated to the rate of occurrence of the calibrator waveform, the displayed waveform will be traced out at a different point on the screen each time the sweep runs. This will either cause the waveform to drift across the screen or to be an unintelligible pattern.

It is desirable for a repetitive waveform to appear stationary on the cathode-ray tube screen so that the characteristics of the waveform can be examined in detail. As a necessary condition for this type of display, the start of the sweep must bear a definite, fixed-time relationship to the appearance of the input waveform. This means that the sweep must be synchronized with the input waveform. For present purposes, the starting of each horizontal wave across the screen can be called "triggering the sweep." This is accomplished with a minimum of adjustments by setting the TRIGGER MODE control to the AUTO SLOW position. These settings are given in Table 2-1 in the preceding paragraph so that we obtained the display in Figure 2-1.

The AUTO FAST position is used when a very high sweep rate is chosen or if the applied signal is greater than 900 cycles. This position will assure a sufficient repetition rate to make the reference trace readily visible, even in the absence of a triggering signal, such as may occur in dual-trace operation.

Because of its simplicity of operation, the AUTOmatic TRIGGER MODE setting is most useful. There is no need to adjust the Main Sweep STABILITY control since it is disconnected when the TRIGGER MODE switch is set to AUTO. The TRIG LEVEL control may remain in its PRESET position for optimum utility, yet may also be used to select any desired triggering level. The TRIG LEVEL control is normally left in the PRESET position.

Switch the Channel A VOLTS/CM switch on the Y Dual Trace to OFF. Notice that the display is just a straight horizontal trace. This desirable reference trace is useful when you are testing equipment by moving a probe or other input connection from point-to-point in the circuit under test. This reference trace, in the absence of a triggering signal, is not obtained when you are using triggering modes other than AUTO.

Return Channel A VOLTS/CM switch to CAL.

e. Effect of the Position Control Located on the Y Plug-In Unit

Set Main SWEEP RATE control to 5 MS. Pull out Channel A VERNIER control and adjust pattern for about two centimeters of vertical deflection. Adjust the INDEX POSITIONING control until the Read-Out dots fall on the waveform as shown in Figure 2-7a.

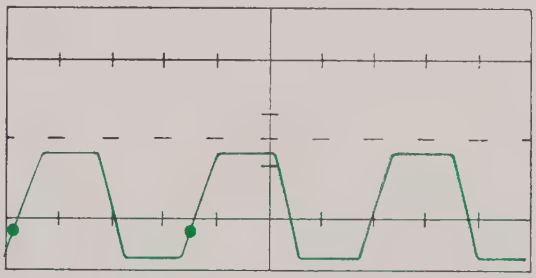


Figure 2-7a. Reference Display

Turn the POSITION control of Channel A back and forth and notice that it lowers and raises the display on screen. Notice especially that as you position the display off screen in either direction, one of the Beam Position Indicator lamps located above the screen will light to indicate the direction in which the display is being positioned. This will indicate the direction in which to turn the POSITION control in order to return the trace to the screen. Reset the POSITION control to return the display to the center of the screen.

Note: Notice that the Read-Out dots are not affected.

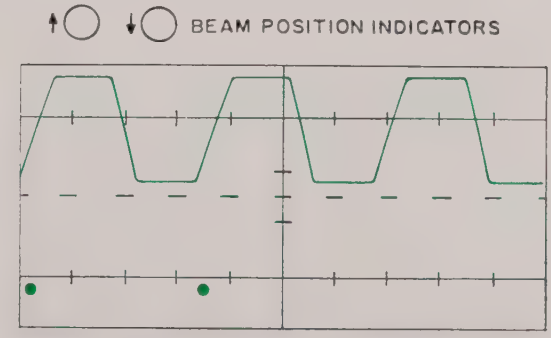


Figure 2-7b. Waveform is Positioned Vertically by the Position Control

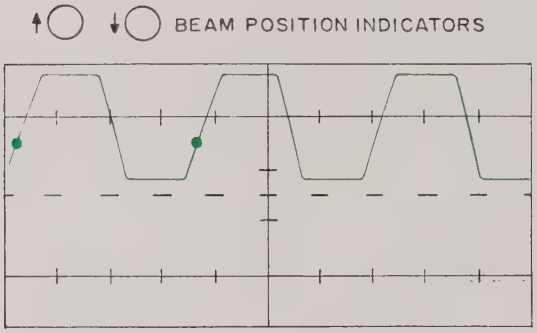


Figure 2-8a. The Entire Display may be Positioned Upward or Downward by the Pattern Position Control

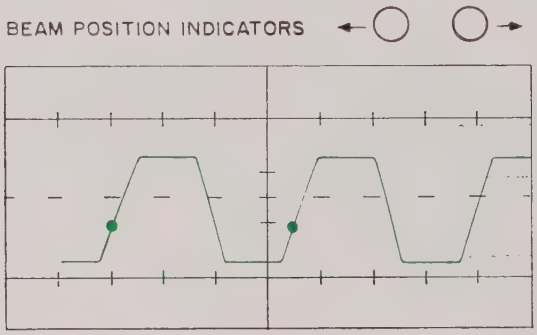


Figure 2-8b. The Entire Display may be Positioned to the Left or to the Right by the Pattern Position Control

g. Effect of the AC/DC Switch Located on the Y Plug-In Unit

Readjust the controls to give the pattern shown in Figure 2-1, by returning the DISPLAY LOGIC switch to MAIN SWP, SWEEP RATE to 1 MS, and pushing in Channel A VERNIER control.

Set VOLTS/CM switch to 0.5. Connect a lead from the CAL 2V jack to the Y Input BNC connector of Channel A. A pattern similar to that shown in Figure 2-1 should reappear. Set the AC/DC switch (or the INPUT SELECTOR switch on single channel Y Plug-ins) to DC. Notice that the trace shifts vertically.

Position the display so that the start of the sweep is centered in the vertical direction. When the AC/DC switch is moved to the AC position, the effect of the DC component is excluded from the display. When the AC/DC switch is set to DC, the ac signal and the dc level of the calibrator waveform will be noted. The dc component of the waveform causes the entire display to rise or fall on the screen. Now reset the AC/DC switch to AC.

f. Effect of the Pattern Positioning Control

Move the PATTERN POSITIONING control up and down. Notice that the waveform and Read-Out dots remain in registration as this control is varied. It will be noted that for about 15 degrees of motion, the level will feel somewhat lighter to the touch than the remaining range. This control incorporates a backlash type vernier feature to simplify exact registration of the pattern with respect to the scale.

The PATTERN POSITIONING control may also be moved in the horizontal direction to position the pattern to the left or to the right. The same vernier action also holds for the horizontal positioning.

The lever controls found in the Du Mont Type 425 Oscilloscope incorporate the latest in human engineering concepts to simplify the number of controls and facilitates measurements. Now, adjust the PATTERN POSITIONING control to return the display to the center of the screen.

h. Effect of the Volts/CM Control Located on the Y Plug-In Unit

Turn the VOLTS/CM knob successively to positions both to the right and to the left of the 0.5 position. Notice that when you set this control to the higher numbered positions, the amplitude of the calibrator waveform is reduced and vice versa.

Reset the VOLTS/CM knob to the 0.5 position. Pull the VERNIER control out and turn it counterclockwise. Notice that the CALibrator lamp is extinguished and that the amplitude of the calibrator waveform is reduced. Push the VERNIER control in and notice that the calibrator waveform is restored to the display of Figure 2-1. Thus, it is seen that when a given voltage is applied to Y Input, the VOLTS/CM and VERNIER controls are used for adjusting the amplitude of the resulting vertical deflection.

i. Effect of the DC Bal Screwdriver Control Located on the Y Plug-In Unit

Set the VOLTS/CM control of Channel A to OFF.

Pull out the Channel A VERNIER knob and rotate it in either direction throughout its range. The reference trace on the screen should not move up or down for any setting of the VERNIER control. If the trace shifts vertically, turn the VERNIER control counterclockwise. Next, while pulling the VERNIER control in and out, carefully adjust the Channel A DC BAL screwdriver control until no movement of the trace is noted. Reset the Channel A VOLTS/CM control to CAL and push in the VERNIER knob. Disconnect the lead between the CAL 2V jack and the Y Input BNC connector of Channel A.

j. Effect of the Main Sweep Rate Control

Turn the Main SWEEP RATE control to the 2 millisecond position. Notice that a complete cycle of the calibrator waveform now is displayed. The display therefore contracts horizontally as you turn the switch in the counterclockwise direction. Reset the SWEEP RATE control to the 1 millisecond position. Now, turn the SWEEP RATE control to the 500 microsecond position. Notice that the display has expanded so that less than a one-half cycle is on display.

Pull out the Main Sweep VERNIER knob and note that the Sweep Rate dial lamp is extinguished, thus warning the operator that the sweep rate is uncalibrated. Reset the SWEEP RATE dial to 1 millisecond per centimeter. Notice that turning the VERNIER control will produce a change in the sweep rate of about 3 to 1. When the applied input signal has a fixed repetition rate, the SWEEP RATE and VERNIER settings determine the number of cycles seen on the display. It will be shown later that the EXPAND switch has a 5 to 1 magnification effect to again modify the previous condition.

k. Effect of the Expand Switch

Push in the Main Sweep VERNIER knob and set the SWEEP RATE dial to 5 milliseconds per centimeter. The pattern indicated in Figure 2-9a should appear on the screen.

Turn the EXPAND knob to the X5 position. Notice the resulting horizontal expansion of the display as indicated in Figure 2-9b.

a. EXPAND switch set to X1.

b. EXPAND switch set to X5.

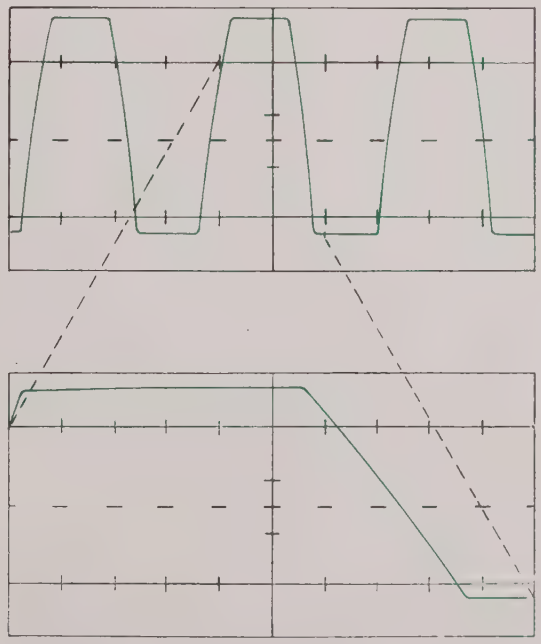


Figure 2-9. Calibrator Waveform Display Illustrating the Effect of the Expand Switch

Turn this switch from X1 to X5 and back several times. Observe that the portion of the waveform that occupies the center 2 centimeters of the scale when this switch is in the X1 position, is expanded to occupy the entire 10 centimeters when the switch is turned to X5.

With the EXPAND switch set to X5, move the PATTERN POSITIONING lever control through its

horizontal range and notice that the display has been expanded beyond the limits of the screen.

Since the Expand switch changes gain in the X Amplifier which follows the Main Sweep generator, the SWEEP RATE settings must be multiplied by 0.2 in order to calibrate the displayed sweep. The Expander Indicator lamp is extinguished to alert the operator that this multiplier must be applied to the SWEEP RATE setting.

When the Horizontal Read-Out switches are used, the Read-Out information will be accurately indicated, regardless of the EXPAND switch setting. The index and scaling Read-Out dots are superimposed on the display when the DISPLAY LOGIC switch is set to R. O. Thus, when the EXPAND switch is set to X5, the dots and the signal pattern are expanded together. Expansion therefore, improves the position of alignment between the dot and the pattern, and results in greater accuracy.

Reset the EXPAND switch to X1.

I. Effect of the Main Sweep Trigger Source Switch

Recenter the pattern with the PATTERN POSITIONING control. Set the Main SWEEP RATE control to 5 milliseconds per centimeter.

One of the purposes of the TRIGGER SOURCE control is to determine whether the sweep is triggered on the rising or falling portion of the input waveform as shown in Figure 2-10.

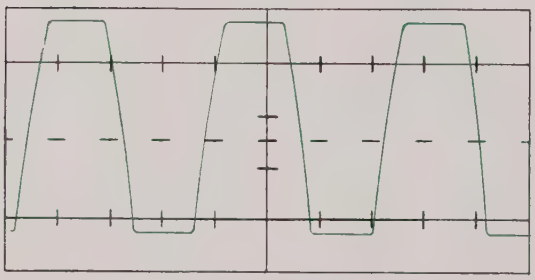


Figure 2-10a. Trigger Source Switch is set to + Line

Carefully observe that part of the display which appears in the left-hand end of this scale. Notice that the trace begins during the rising portion of the waveform; that is, the sweep is triggered at a time when the slope of the waveform is positive.

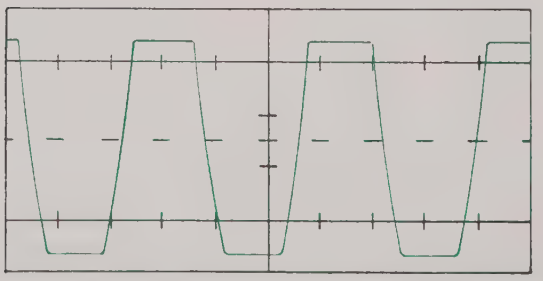


Figure 2-10b. Trigger Source Switch is set to — Line

Observe that the display appears to turn upside down so that it now begins during a falling portion of the waveform at the left-hand end of the scale; thus, the sweep is triggered at a time when the slope of the waveform is negative. Reset TRIGGER SOURCE switch to + LINE.

m. Effect of the Main Sweep Trig Level Control

The TRIG LEVEL control determines the height (or level) on the waveform where the display starts. Since the TRIGGER SOURCE switch is set to + LINE, the displays shown in Figure 2-11 start on the rising part of the waveform where the slope is positive.

If you set the TRIG LEVEL control more towards the counterclockwise part of its range, the display starts on the lower part of the waveform as indicated in Figure 2-11a.

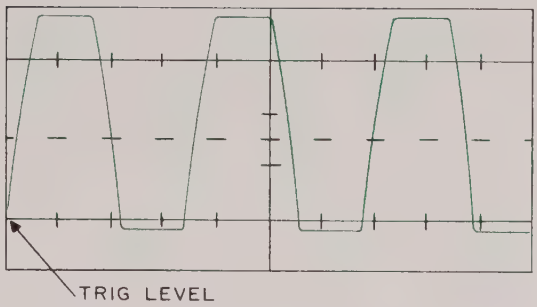


Figure 2-11a. Effect of Trig Level Control When Slope is Positive

If you set the TRIG LEVEL control more towards the clockwise part of its range, the display starts on a higher part of the waveform as indicated in Figure 2-11b.

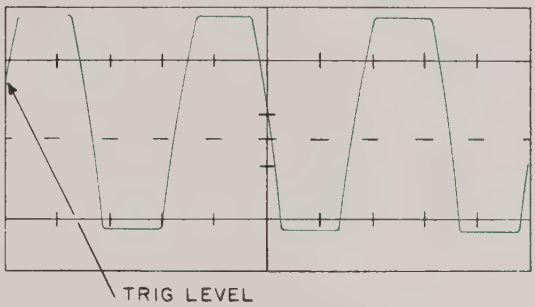


Figure 2-11b. Effect of Trig Level Control When Slope is Positive

Turn the TRIGGER SOURCE switch to — LINE so that the waveform appears upside down. The display now begins during a falling part of the waveform where the slope is negative. Note that you can still control the height of the point where the trace starts by means of the Main Sweep TRIG LEVEL control as indicated in Figures 2-12a and 2-12b.

If you set the TRIG LEVEL control more towards the clockwise part of its range the display starts on a higher part of the waveform as indicated in Figure 2-12a.

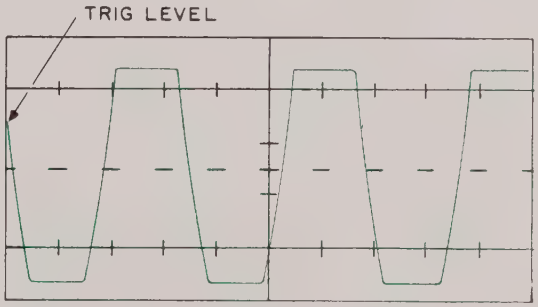


Figure 2-12a. Effect of Trig Level Control When Slope is Negative

If you set the TRIG LEVEL control more towards the counterclockwise part of its range, the display starts on the lower part of the waveform as indicated in Figure 2-12b.

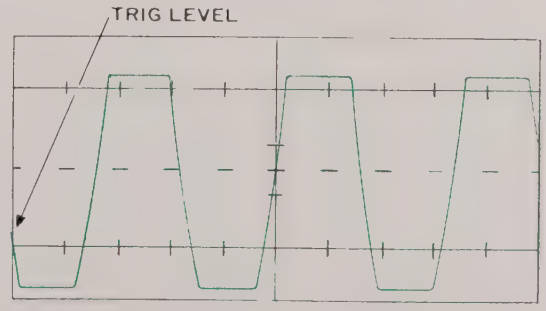


Figure 2-12b. Effect of Trig Level Control When Slope is Negative

Set TRIGGER SOURCE switch to + LINE and TRIGGER MODE switch to NORMAL AC. Pull out the Channel A VERNIER control and adjust the display for about two centimeters of vertical deflection. Now turn the Channel A POSITION control back and forth so that the display moves up and down on the screen. Observe the left-hand end of the display while you do this. Notice that, for a fixed setting of the Main Sweep TRIG LEVEL control, the trace always starts on a given point on the waveform regardless of the setting of the POSITION control as shown in Figure 2-13.

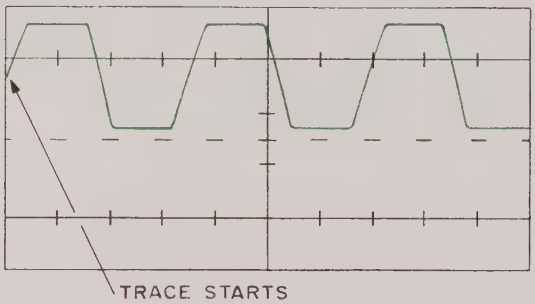


Figure 2-13a. Vertical Positioning in the Normal AC Mode

Display is positioned upward.

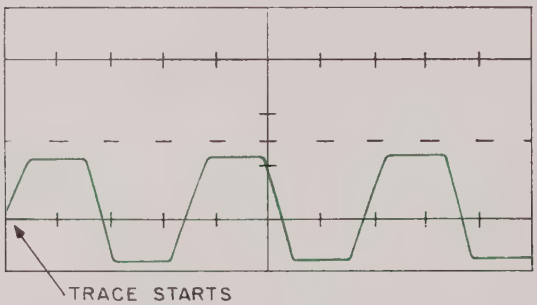


Figure 2-13b. Vertical Positioning in the Normal AC Mode

Display is positioned downward. Note that the start of the trace is the same regardless of the vertical centering.

Check that the STABILITY control is set to PRESET and push in Channel A VERNIER control. Set the TRIGGER MODE control to NORMAL AC. Turn the Main Sweep TRIG LEVEL control from its PRESET position and slowly rotate it one complete revolution. Notice that the SYNC READY lamp is on for one-half of the rotation and is off the remaining half. Turn the TRIG LEVEL control completely clockwise; note that the SYNC READY lamp is lit. Slowly turn the TRIG LEVEL control counterclockwise until a stable pattern appears.

It becomes apparent that the SYNC READY lamp can be set at the point where it is just on and with no signal applied. This point then is the most sensitive sync point. It also has been noted that the TRIG LEVEL control, if turned to discriminate against signals larger than the one admitted to the trigger channel, will prevent the sweep from triggering. The PRESET TRIG LEVEL position, therefore, is very useful for eliminating baseline noise or setting a discrete triggering point on the waveform.

The TRIG LEVEL control features a backlash vernier action for fine selection of the triggering point. Note too, that the TRIG LEVEL control now can check the trigger level at any point on the waveform and when this control is turned too far, the sweep will disappear. A TRIG LEVEL control has a discrimination range of about ± 20 volts for external sync. Signals of smaller amplitude may therefore be completely eliminated.

2-6. SUMMARY OF AUTOMATIC AND AC TRIGGERING MODES

The following summary statements may be made to compare the AC and the AUTO modes of triggering:

1. The TRIG LEVEL control may be used to select the level of the triggering point for all settings of the TRIGGER MODE switch. A PRESET position is provided on the TRIG LEVEL control to simplify operation and to optimize trigger channel sensitivity.

2. When using the AUTO SLOW mode, a horizontal reference trace will appear on the screen, even in the absence of an input signal. This automatic mode is very useful while testing equipment since a reference trace will always be visible during the time no signal is applied to the oscilloscope. The AUTO SLOW mode simplifies synchronization for signals having repetition rates greater than 50 cycles.

3. When using the AUTO FAST mode, the reference trace becomes more visible at higher sweep rates. The AUTO SLOW and FAST modes are handy when Y dual-trace operation is used, and the sync signal applied to either Channel A or to Channel B is intermittent. The AUTO FAST simplifies synchronization for signals having repetition rates greater than 900 cycles.

4. The AC mode may be used for general trigger source coupling. The low-frequency cutoff is approximately 80 cycles to avoid disturbing internal triggering while vertically positioning the pattern.

5. The ACF trigger mode, with its low-frequency cutoff at 15,000 cycles is designed primarily to reject low-frequency amplitude modulations in the trigger source; and to remove the positioning level between the two traces in dual-trace and other time-shared displays when using internal trigger source.

6. When using AC or ACF triggering mode and internal triggering, no trace appears when there is no input signal applied to the oscilloscope. In dual-trace operation, it will be obvious that the electronic switches will then rest in the channel which temporarily has no signal. In this case, use of the AUTO mode will always maintain a display on screen.

7. The AUTO mode is useful while observing periodic waveforms. The AC modes are useful for both periodic waveforms and for waveforms which occur only once, or at random, widely-spaced intervals.

8. For most uses, the AC mode is preferable to the ACF mode. For all applications where internal synchronization is required from dual trace or multiple function time-shared displays (for example, Read Out), the ACF mode should be used. The coupling to the trigger circuits when AUTO trigger mode is used has the same time constant as the AC trigger mode.

9. Always use the ACF mode when displaying Read Out on internal triggering to avoid triggering distorion when positioning the Read Out. If a low-frequency signal which does not trigger via ACF is to be displayed, use External Trigger Source. If the Read-Out dots blink while on internal triggering, also use External Trigger Source.

2-7. DC TRIGGERING MODE

After completing the previous operation, use the POSITION control on the Y Plug-in Unit to center the display vertically on the screen. Set the TRIGGER SOURCE switch to + INT and the Main Sweep TRIG LEVEL control to PRESET. Turn the TRIGGER MODE switch to NORMAL DC. You are now triggering the sweep in the DC mode.

Slowly turn the TRIG LEVEL control throughout its range. Carefully observe the left hand end of the display while you do this. Note that the results are very much like those obtained when using the AC mode. Set the TRIGGER SOURCE switch to — INT and repeat the above operation. Again note the results are similar to those obtained when using the AC mode. Reset the TRIGGER SOURCE switch to + INT and the TRIG LEVEL control to PRESET.

Now move PATTERN POSITIONING lever control up and down so that the display is moved vertically on the screen. Observe the left-hand end of the display while you do this. Notice that for a given setting of the Main Sweep TRIG LEVEL control, the trace starts at a given point on the Scale regardless of the PATTERN POSITIONING setting. If you position the trace too high or too low so that the waveform does not include this setting, the trace disappears. See Figure 2-14.

The following statements may be made to compare the DC and AC modes of triggering:

1. When you use the DC mode, the trace always starts at a given point on the *Scale* for a given Main Sweep TRIG LEVEL setting regardless of the vertical centering. However, when you use the AC mode, the trace always starts at a given point on the *waveform* for a given Main Sweep TRIG LEVEL setting regardless of the vertical centering.

2. The DC mode is especially useful for viewing waveforms which change very slowly and which are, therefore, discriminated against by the low-frequency cutoff of the AC position. Because of the coupling network time constant in the AC mode, signals having random repetition rates are sometimes viewed more stably in the DC mode.

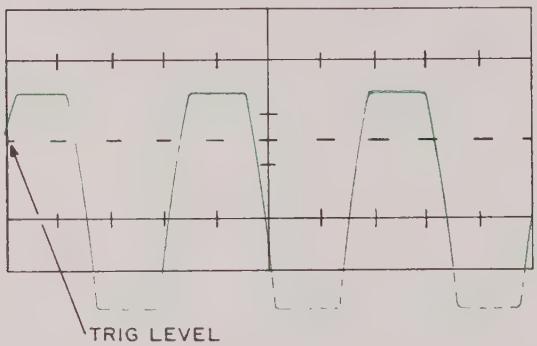


Figure 2-14a. Vertical Positioning in the Normal DC Mode

Display is positioned downward.

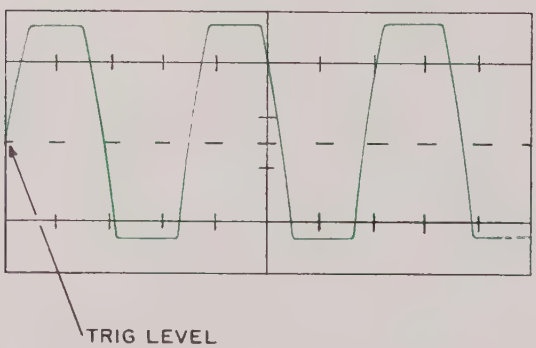


Figure 2-14b. Vertical Positioning in the Normal DC Mode

Display is centered.

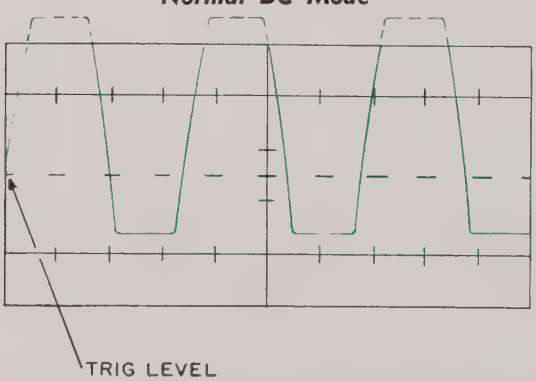


Fig. 2-14c. Vertical Positioning in the Normal DC Mode

Display is positioned upward.

2-8. SINGLE SWEEP

a. Armed Operation (Manual or Remote Reset)

Set the TRIGGER MODE switch to ARMED AC. Turn the TRIGGER SOURCE switch on the Delaying Sweep Unit to OFF. Push in the ARMED SWP RESET button. A single sweep should appear with a constant synchronization point each time the button is pushed in.

Turn the Main Sweep TRIGGER SOURCE switch to — EXT/10. Push in the ARMED SWP RESET button. The SWP READY lamp should now be on, thereby indicating that the Main Sweep is armed and ready to fire on the next trigger. Apply a trigger by returning the Main Sweep TRIGGER SOURCE switch to + INT. A single sweep should occur. Repeat the operation by returning the TRIGGER SOURCE switch to — EXT/10, and rearm the Main Sweep by pushing the ARMED SWP RESET button. A single sweep will again occur when the TRIGGER SOURCE switch is set to + INT.

NOTE: The switching transient within the TRIGGER SOURCE switch will probably transfer with the trigger leveling action and will result in random level selection for this illustrative example. In normal use, the TRIGGER SOURCE switch need not be turned, but is left at the desired source position. The trigger signal following the rearm operation will then fire the sweep.

The sweep may be armed remotely by means of a contact closure (or a 100-volt negative fast rising pulse) introduced through the 2-contact socket, J6700, located on the top of the instrument.

The DELayed TRIGger output is internally connected to parallel with the ARMED SWP RESET push button, so that this delayed trigger may also rearm the sweep. When using the remote or manual single sweep reset feature, the delayed trigger must not be functioning. (Turn PICKOFF SOURCE switch to OFF or shut off Delaying Sweep as indicated above) or undesired random rearming will result.

Thus, it has been shown that (1) the ARMED SWP RESET push button or the Delaying Sweep Delayed Trigger will arm the Main Sweep and (2) the next suitable trigger fires the Main Sweep when the Main Sweep STABILITY control is set to PRESET (which is triggered operation).

b. Triggered Operation (Manual or Remote Reset)

Set the Main Sweep STABILITY control to RECurrent and the Main Sweep TRIGGER SOURCE switch to OFF. Push in the ARMED SWP RESET button. A single sweep should appear on screen in random fashion for trigger level selection each time the button is pushed in. Remote firing of a single sweep through J6700 (as described above) is also feasible.

The Delaying Sweep Pick-Off Trigger Generator may be used to arm the Main Sweep as follows: Set the PICK-OFF SOURCE switch to DEL SWP. The Main Sweep is then fired at the point of arming when the Main Sweep STABILITY control is set in the RECurrent mode for manual operation. The number of cycles of the display seen on the screen is a function of the Main SWEEP RATE control. However, the flicker rate or the number of times the Main Sweep is armed and fired, is a function of the Delaying SWEEP RATE control.

2-9. DISPLAYING A SIGNAL BY MEANS OF THE DU MONT TYPE 4203 DELAYING SWEEP PLUG-IN UNIT

a. Delaying Sweep Operation

In this mode of operation, the Delaying Sweep, rather than the Main Sweep, is used for horizontal deflection. The Delaying Sweep is applied instead of the Main Sweep when the DISPLAY LOGIC switch is set to DELAYING SWP. Set the controls as indicated in Table 2-2.

TABLE 2-2

DELAYING SWEEP SETUP

CONTROL	SETTING
MAIN FRAME	
DISPLAY LOGIC	DELAYING SWP
SWEEP RATE	1 MS/CM
STABILITY (TRIG/REC)	RECurrent
TRIGGER MODE	ARMED AC
EXPAND	X1
DELAYING SWEEP PLUG-IN	
PICK-OFF SOURCE	OFF
LENGTH	Fully cw
SWEEP RATE	5 MS/CM
TRIGGER SOURCE	+ LINE
TRIGGER MODE	AC
TRIG LEVEL	PRESET
STABILITY (TRIG/REC)	PRESET
DELAY MULTIPLIER	3.00
Y DUAL TRACE PLUG-IN	
VOLTS/CM	CAL
INPUT SELECTOR	A

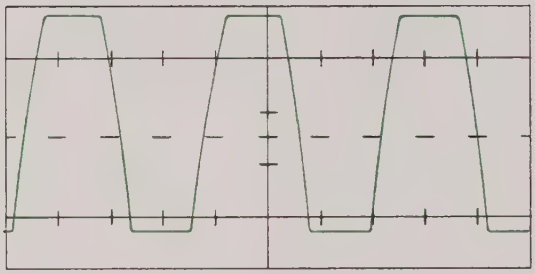


Figure 2-15. Calibrator Waveform Display with the Display Logic Switch Set to Del Swp

Now adjust the INTENSITY and PATTERN POSITIONING controls until the pattern of Figure 2-15 is displayed.

Operate the following controls, and note that they function in the same way as they did when the Main Sweep was used: POSITION, PATTERN POSITIONING, AC/DC switch (or AC and DC positions of the INPUT SELECTOR switch), VOLTS/CM and the EXPAND switch.

Turn the Delaying SWEEP RATE knob successively to positions both to the right and left of the 5 milliseconds position. Notice that the Delaying SWEEP RATE switch provides control of the number of cycles of the display that appear on the screen when a waveform having a fixed repetition rate is presented by means of the Delaying Sweep.

Reset the Delaying SWEEP RATE knob to 5 milliseconds per centimeter. Set the Delaying TRIGGER SOURCE switch from + LINE to — LINE and observe that this switch provides control over the beginning rise or fall of the calibrator waveform. This operation is similar to that involved when you used the Main Sweep TRIGGER SOURCE control. (See Figure 2-10.)

b. Delayed Main Sweep Operation

After completing the Delaying Sweep Operation as indicated in the preceding paragraph, turn the PICK-OFF SOURCE switch to DEL SWP and adjust the INTENSITY control until the Figure of 2-16a appears on the screen.

Set the DELAY MULTIPLIER control to 000 and adjust the 10-turn DELAY ZERO control until the strobe just disappears on the left hand side of the trace. This operation calibrates the DELAY MULTIPLIER control. Reset the DELAY MULTIPLIER to 3.00.

The portion of the display between 3 and 5 centimeters of the start of the Delaying Sweep should be brighter than the rest of the display. Notice that the INTENSITY control has a built-in backlash feature permitting individual control of the levels of intensity in the brightened and normal patterns of the display. Again, readjust the INTENSITY control so that the strobe is readily visible on the Delaying Sweep with a minimum of defocusing.

Now turn the DISPLAY LOGIC switch to MAIN SWP. The portion of the original display that was brightened will now be expanded to fill the entire scale as indicated in Figure 2-16b. Thus, it is seen that when the Main Sweep TRIGGER MODE is in the ARMED position, the DISPLAY LOGIC switch is set to MAIN SWP, the PICK-OFF SOURCE switch is set to DEL SWP, the display on the screen will be a Delayed Main Sweep. Move the middle thumb wheel of the DELAY MULTIPLIER through one revolution and observe that the display is truly delayed (phased) by the Delaying Sweep. Reset the DELAY MULTIPLIER to 3.00 and the DISPLAY LOGIC switch to DELAYING SWP. Figure 2-15 should reappear.

a. DISPLAY LOGIC switch set to DELAYING SWP.

b. DISPLAY LOGIC switch set to MAIN SWP. (Strobe is magnified X5.)

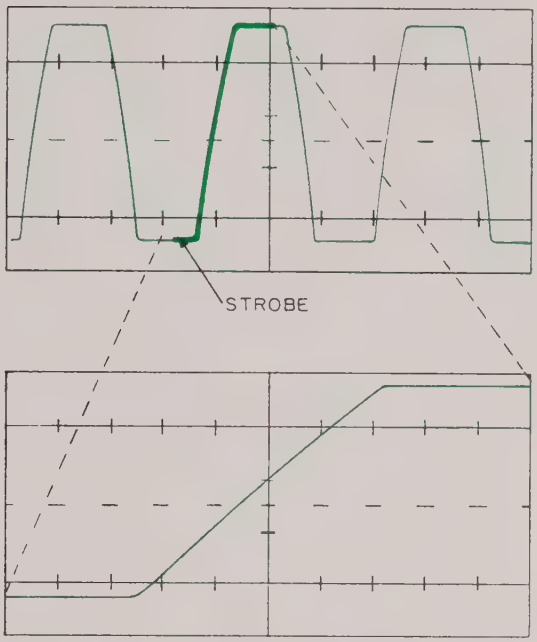


Figure 2-16. Calibrator Waveform Display with the Pick-Off Source Switch Set to Del Swp and Illustrating Magnification of the Strobe

The amount of the delay occurring from the application of the triggering signal until the sweep starts, is indicated directly by the setting of the Delaying SWEEP RATE and DELAY MULTIPLIER controls. The setting of these two controls are multiplied together to obtain the actual delay time. For example, if the Delaying SWEEP RATE is set to 5 MS and the DELAY MULTIPLIER is set to 3.00, the delay time is 15 milliseconds. Note that the above applies only when manual triggered operation is used and the Main Sweep STABILITY control is set to RECurrent.

Turn the Main SWEEP RATE control one position in each direction. Notice that the starting point of the brightened portion of the trace (strobe) is not affected but that the greater the sweep rate, the shorter the brightened section becomes; see Figure 2-17a. The slower the sweep rate, the longer the brightened section becomes; see Figure 2-17c.

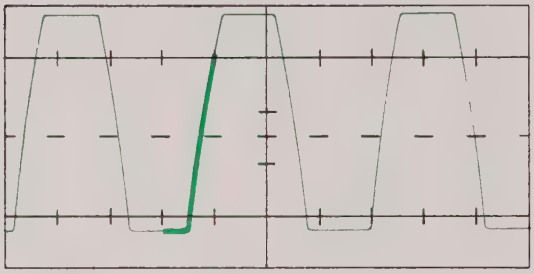
Reset the Main SWEEP RATE to 1 millisecond. Now reduce the length of the Delaying Sweep with the LENGTH control until the Delaying Sweep is foreshortened into the strobe region. Decreasing the Delaying Sweep length further will cause the strobe to intensify the retrace of the Delaying Sweep. This condition is abnormal.

The LENGTH control must always be adjusted so that the Delaying Sweep extends slightly to the right of the intensified strobe.

The above instructions have made it clear that the strobe is equal to the sweep time of the Main Sweep and that the left-hand side indexes the time delay of the Main Sweep from the start of the Delaying Sweep. Since the Main Sweep represents a section in time within the Delaying Sweep display, and since this section may be expanded to full scale, we may now consider the Main Sweep as a calibrated, magnified section of the Delaying Sweep. The magnification ratio may be expressed as follows:

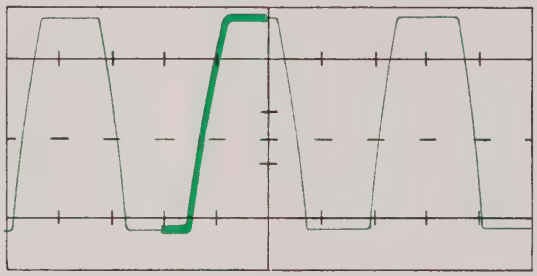
$$\text{Magnification Ratio} = \frac{\text{Delaying Sweep Rate (Time/cm)}}{\text{Main Sweep Rate (Time/cm)}}$$

The previous example, Figure 2-16b shows a magnification of 5 to 1.



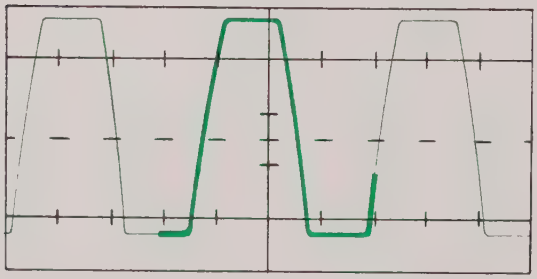
Main SWEEP RATE control set to 500 us.
Note: Strobe is shorter than Figure 2-17b.

Figure 2-17a. Effect of Main Sweep Rate Control on Strobe Length



Reference Display Main SWEEP RATE control set to 1 MS.

Figure 2-17b. Effect of Main Sweep Rate Control on Strobe Length



Main SWEEP RATE control set to 2 MS.
Note: Strobe is longer than Figure 2-17b.

Figure 2-17c. Effect of Main Sweep Rate Control on Strobe Length

c. Delayed-Triggered and Delayed-Armed Modes of Main Sweep Operation

Following the instructions of the previous paragraph, the display illustrated in Figure 2-16a should now appear on the screen. Again, set the DISPLAY LOGIC switch to MAIN SWP and note that the section indicated as a strobe is magnified to fill the entire screen, as shown in Figure 2-16b. Reset the DISPLAY LOGIC switch to DELAYING SWP.

Now turn the Main Sweep TRIGGER MODE switch to AC NORMAL. No change should appear in the display from that of Figure 2-16a. Now again set the DISPLAY LOGIC switch to MAIN SWP and notice that the strobe section is running free (not synchronized), thus making the display indistinguishable. Therefore, to observe only the Delayed Main Sweep, the DISPLAY LOGIC switch is set to MAIN SWP, and the Main Frame TRIGGER MODE switch is in the ARMED position. These settings permit the Main Sweep to be automatically rearmed by the Delaying Sweep pick-off trigger. Reset the DISPLAY LOGIC switch to DELAYING SWP.

Whenever the Main Sweep is delayed, its trigger

mode is armed. The Delayed Main Sweep has two operating modes. One of these modes is available when the Main Sweep STABILITY control is set to RECurrent. In this mode, the Main Sweep starts directly at the delay time indicated by the DELAY MULTIPLIER and Delaying SWEEP RATES control settings. This mode from now on will be referred to as the *delayed-triggered* sweep mode of operation.

The delayed-triggered mode permits you to select continuously variable delay times and is the mode of operation used to make accurate time and waveform jitter measurements as well as most other measurements.

The second mode is available when the Main Sweep STABILITY control is turned to PRESET. In this mode, the Main Sweep does not start precisely at the delay time indicated by the DELAY MULTIPLIER and Delay SWEEP RATE control setting; but instead, is initiated by the next suitable trigger following the indicated delay interval. This mode from now on will be referred to as the *delayed-armed* mode of sweep operation.

The delay time in this mode is not continuously variable and should be used whenever the signal to be displayed has cumulative time jitter between the start of the Delaying Sweep and the delayed magnified section. Since the sweep is triggered by the input signal, jitter is eliminated from the display even though it is inherent in the input waveform.

d. Simultaneous Display of the Delaying Sweep and the Magnified Delayed Main Sweep

The displays of Figure 2-18 indicate the unique feature of the Du Mont Type 425 Oscilloscope. This instrument is capable of displaying a waveform which indicates a section to be magnified and, at the same time, displaying the fully magnified section without the need for manual switching.

Reset the STABILITY control to RECurrent and leave the other controls as they are. Pull out the Channel A VERNIER control on the Y Plug-in and adjust the amplitude of the display to about two centimeters. Set the DISPLAY LOGIC switch to MAIN SWP AND DELAYING SWP and adjust the SWEEP SEPARATE screwdriver control to simulate Figure 2-18a.

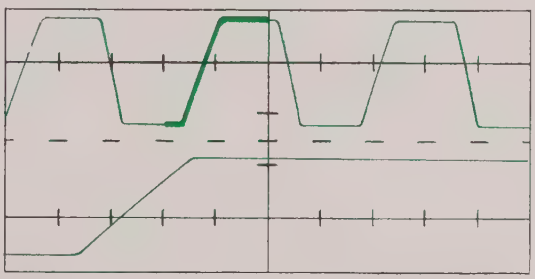


Figure 2-18a. Delaying Sweep Length is Set to 10 CM

Notice that the display flicker rate is low and that two sweeps appear to alternate successively. Flicker may be reduced by shortening the Delaying Sweep duration with the LENGTH control. See Figure 2-18b.

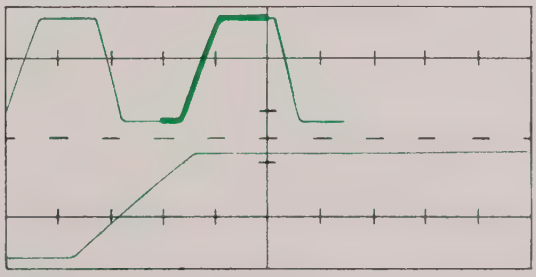
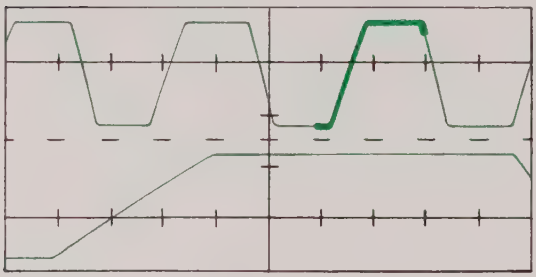


Figure 2-18b. Delaying Sweep Length is Set to Less than 10 CM

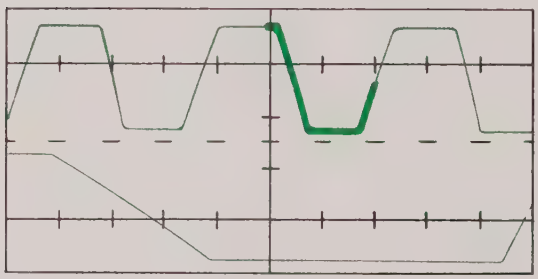
Set the Main Sweep STABILITY control to PRESET and the Delaying Sweep LENGTH to 10 CM.

Now set the Main Sweep TRIGGER SOURCE switch from + LINE to — LINE. Notice in Figures 2-19a and 2-19b that the starting point of the magnified section and its slope have shifted which indicates the delayed-armed mode of sweep operation. Reset TRIGGER SOURCE switch to + LINE.



TRIGGER SOURCE set to + LINE.

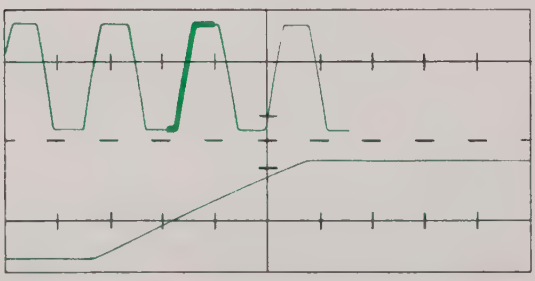
Figure 2-19a. Illustrating Change in Starting Point of Strobe When Stability Control is Set to Preset



TRIGGER SOURCE set to — LINE.

Fgure 2-19b. Illustrating Change in Starting Point of Strobe When Stability Control is Set to Preset

Set the Delaying SWEEP RATE control to 10 MS. Turn the DELAY MULTIPLIER to the settings indicated in Figure 2-20. Notice that the starting point of the magnified section is the same point on each cycle. This indicates that the signal triggers the Main Sweep after a fixed period of delay and illustrates the delayed-armed mode of sweep operation.



Set DELAY MULTIPLIER to 3.00. (Note: Main Sweep STABILITY control is set to PRESET.)

Figure 2-20a. Illustrating the Delayed-Armed Mode of Sweep Operation

Set DELAY MULTIPLIER to 4.00.

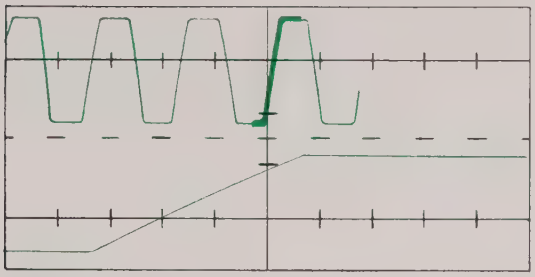


Figure 2-20b. Illustrating the Delayed-Armed Mode of Sweep Operation

Set DELAY MULTIPLIER to 5.00.

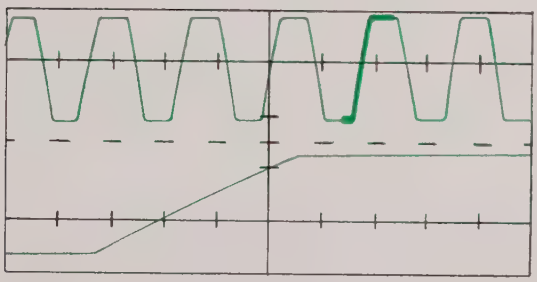


Figure 2-20c. Illustrating the Delayed-Armed Mode of Sweep Operation

Set the Main Sweep STABILITY control to RECurrent and the Delaying SWEEP RATE control to 5 MS. Turn the DELAY MULTIPLIER to the settings indicated in Figure 2-21. Notice that the strobe progresses smoothly and starts directly at the delay time indicated by the DELAY MULTIPLIER and Delaying SWEEP RATE control settings. This indicates the delayed-triggered mode of sweep operation.

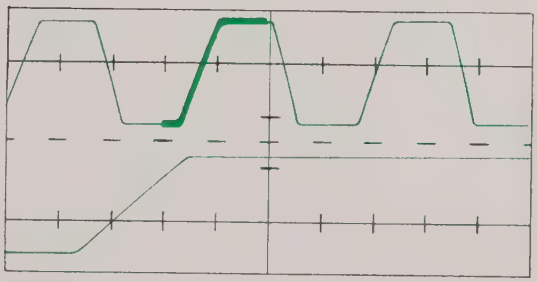


Figure 2-21a. Illustrating the Delayed-Triggered Mode of Sweep Operation

Set DELAY MULTIPLIER to 3.00. (Note: Main Sweep STABILITY control is set to RECurrent.)

Set DELAY MULTIPLIER to 4.00.

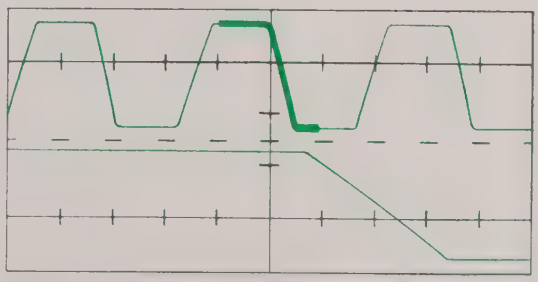


Figure 2-21b. Illustrating the Delayed-Triggered Mode of Sweep Operation

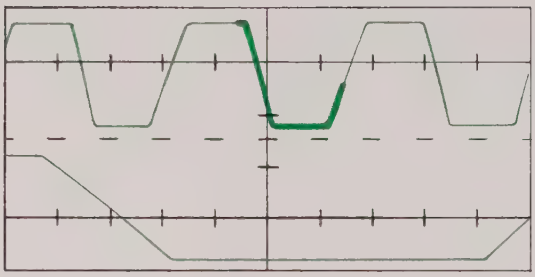


Figure 2-21c. Illustrating the Delayed-Triggered Mode of Sweep Operation

Set DELAY MULTIPLIER to 5.00.

2-10. SUMMARY OF FRONT-PANEL FACILITIES

Table 2-3 tabulates the function of controls and connectors for the Type 425 Deluxe Main Frame Module. A tabulation for the Plug-in Units will be found in their respective Instruction Manuals.

The following controls have backlash type vernier adjustments for optimum resolution:

1) PATTERN POSITIONING lever control

2) INDEX POSITIONING lever control

3) INTENSITY control

4) TRIG LEVEL control

TABLE 2-3
FUNCTION OF CONTROLS AND CONNECTORS

NAME	FUNCTION
DELUXE MAIN FRAME MODULE	
DISPLAY LOGIC	**Concentric Controls:** a. **Large knob:** six-position switch arranges the internal electronic switches for the following displays: (1) X Amplifier (2) Read Out with Main Sweep (3) Main Sweep (4) Main Sweep and Delaying Sweep (5) Delaying Sweep (6) Independent Displays Additional information will be found in the text.
EXPAND	b. **Small knob:** two-position switch removes and inserts feedback in the X Amplifier to which sweep rates or X Amplifier sensitivities are changed by a factor of 5. An indicator light is provided to show the X1 position. All sweep-rate settings must be multiplied by 0.2 when the EXPAND switch is set to X5.

TABLE 2-3. FUNCTION OF CONTROLS AND CONNECTORS (Continued)

NAME	FUNCTION
	Concentric Controls:
TRIGGER SOURCE	a. **Large knob:** nine-position switch which selects the source and slope for triggering as follows: They are: ± LINE; ± INTernal; ± EXTernal attenuated by a factor of 10; ± EXTernal direct, and OFF.
TRIG LEVEL	b. **Small knob:** Potentiometer determines at what voltage on the input triggering waveform the horizontal trace will start. A PRESET position is provided in the counterclockwise direction which provides fixed optimized sensitivity.
EXT SYNC	BNC coaxial connector to triggering circuits through EXTernal positions of the TRIGGER SOURCE switch.
SYNC READY	Indicator lamp: this lamp is lit whenever the trigger channel is ready to accept signals. This light serves as a check on the TRIG LEVEL control setting.
SWEEP CAL	Screwdriver control used to standardize accurately the steps of the SWEEP RATE switch. (**Note:** This adjustment is not normally required and should not be used unless an accurate time standard or precise and stable power-line frequency is available.)
	Concentric Controls:
SWEEP RATE	a. **Large knob:** a twenty-four position switch which (1) selects timing networks to determine sweep rates, (2) selects lockout timing capacitors to determine duration of the trigger hold-off period, and (3) selects multiplying factors on the Horizontal Read-Out control. Uncalibrated operation is indicated by extinction of the SWEEP RATE dial light when sweep VERNIER knob is pulled out.
VERNIER	b. **Small knob:** provides a 3 to 1 continuous variation of the indicated SWEEP RATE dial setting. This fine control of the sweep rate is only available when the VERNIER knob is pulled out.
GATE OUT	BNC coaxial connector supplying a 20-volt positive pulse through a cathode follower. The pulse duration is synchronized with the Main Sweep. The output may be used to calibrate test probes. (See Section 3, Applications.)
SWEEP SEPARATE	Front panel screwdriver control to permit separation of the Main Sweep and Delaying Sweep patterns when the DISPLAY LOGIC switch is set to the MAIN SWP AND DELAYING SWP position.
	Concentric Controls:
TRIGGER MODE	a. Large knob: nine-position switch which selects the operating conditions of the Main Sweep trigger circuits. These positions are described below:
1. TRIGGER MODE set to NORMAL	Three NORMAL triggering mode positions provide: (1) DC coupled triggers. (2) AC coupled triggers with a low-frequency cutoff of 80 cycles. (3) ACF (ac fast) coupled triggers with a low-frequency cutoff of 15,000 cycles. This mode is used whenever time-shared phenomenon are presented on internal triggering, and to stabilize triggering from fast-rise signals containing undesirable low-frequency amplitude modulating components.
2. TRIGGER MODE set to HF	This operating mode is used for signals of very high frequency and repetition rate. Normally used for synchronization on sine waves from 5 to 50 megacycles and used in conjunction with RECurrent mode of the STABILITY control.
3. TRIGGER MODE set to AUTO	Two AUTO triggering mode positions provide: (1) SLOW; this mode is used for triggering on signals having a repetition frequency greater than 50 cycles. (2) FAST; this mode is used for triggering on signals having a repetition frequency greater than 900 cycles. This position is used to indicate a brighter base line when high sweep rates are employed.

TABLE 2-3. FUNCTION OF CONTROLS AND CONNECTORS (Continued)

NAME	FUNCTION
4. TRIGGER MODE set to ARMED	Triggering modes similar to the DC, AC and ACF of NORMAL, yet permitting single-shot operation of the Main Sweep. The Main Sweep may be rearmed in the following manner: (1) Manually with the ARMED SWP RESET button. (2) By means of contact closures through the camera accessory socket EXT RESET (J6700: two-pin socket located on top of the instrument). A 100-volt negative fast-falling pulse (with less than 1 us) may also be introduced into J6700 for electronic reset. (3) Electronically from the Delaying Sweep Plug-in.
STABILITY (TRIG/REC)	b. **Small knob:** control for adjusting the Main Sweep for TRIGgered or RECurrent operation and is provided with a PRESET position suitable for most triggering applications. This control should only be used in the HF position of the TRIGGER MODE switch and for stabilizing high repetition rate and random signals which affect the critical lock-out period of the Main Sweep.
SWEEP READY	Indicator: lamp is lit when the Main Sweep is armed and ready to accept the triggering signal.
ARMED SWEEP RESET	Momentary push button is depressed to reset the Main Sweep when TRIGGER MODE switch is set to ARMED position.
SWITCH MODE	Two-position push-button switch which permits selection of ALTERNATE sweep synchronization of internal electronic switches or 100 Kc free-running (CHOPped) operation of the electronic switches. **CAUTION:** Triggering instability will result when using CHOPped operation and internal triggering. The CHOPped mode reduces visual flicker at low time-sharing rates and should not be used when sweep rates in excess of 1 ms/cm are displayed.
	Concentric Controls:
POLARITY	a. **Large knob:** two-position switch used with Read Out for selecting measurements of positively sloping waveforms.
ASTIG	b. **Small knob:** adjustable voltage for the cathode-ray tube to optimize spot shape.
PATTERN POSITIONING	Single lever control which permits positioning the display in the horizontal and vertical directions, for registration of the pattern with the scale. A backlash type vernier feature is included in both axes for precise orientation.
BEAM POSITION INDICATORS	These indicators are unlabeled but are marked with arrows. The arrow nearest the illuminated indicator shows the direction in which the beam is off the screen.
POWER	On-off toggle switch in primary circuit of power transformers and ventilating fan.
FOCUS	Adjustable voltage for the cathode-ray tube focus grid to optimize spot size.
INTENSITY	Backlash potentiometers adjust the brightening gate level for setting display intensity individually and differentially on time shared and strobed displays. **NOTE:** For all positions of the DISPLAY LOGIC switch except X AMPlifier, an internal INTENSITY LIMIT adjustment (R1000) will prevent illumination on the cathode-ray tube without an operating sweep. This LIMIT control serves as a safety device to prevent CRT screen damage.
Z INPUT	Electrical access to the cathode-ray tube cathode is available internally from the high voltage power supply module. The connector connects through a high voltage capacitor. Input impedance is 8,000-15,000 ohms with a discharge time constant of about 15 milliseconds. A positive voltage greater than 10 volts peak will start to blank the trace. Always use the Z-Axis connector when the X Axis is not used for modulating the trace.
DEFLECTION PLATES ACCESS	Access to the deflection plates is available through a plug button in the side covers near the delay line section of the Y Amplifier module. An accessory direct input fixture is available.

TABLE 2-3. FUNCTION OF CONTROLS AND CONNECTORS (Continued)

NAME	FUNCTION
READ-OUT AREA ON DELUXE MAIN FRAME MODULE	
(VERTICAL R. O.)	Three-thumb activated digital decade switches with indicating lights for decimal points, multipliers, and polarity.
(HORIZONTAL R. O.)	Three-thumb activated digital decade switches with indicating lights for decimal points, and multipliers.
	NOTES ON READ OUT:
	When the DISPLAY LOGIC switch is set to R. O., two dots are displayed on the screen. These two dots may be moved in unison with the INDEX POSITIONING control. One dot, called the indexing dot, will be positioned on a reference part of the waveform to be measured. The other or scaling dot is maneuvered by means of the (HORIZONTAL & VERTICAL R. O.) switches to the desired point on the waveform from which measurements are to be taken. When the two dots are positioned, the exact time (seconds, milliseconds, microseconds) and amplitude (volts and millivolts) of the spacing between the two dots are read directly from the Read-Out area on the front of the oscilloscope. Use of VERNIER controls uncalibrates the Read Out and all Read-Out lamps are extinguished as a warning when the VERNIER controls are activated.
	Concentric Controls:
SCALE	a. **Large knob:** an adjustable series resistor controls the voltage across scale illuminating lamps. A counterclockwise OFF position is provided as well as 10 equal intensity reset points.
R. O. VERNIER	b. **Small knob:** fourth digit interpolating control for the horizontal Read Out.
10-90% ALIGNMENT	Momentary push-button switch which, when depressed, will reduce the vertical Read Out to the 10% and 90% points of the normal setting. Pushing this button will uncalibrate the vertical Read Out by 20% error and the indicating lamps in the vertical Read Out become extinguished as a warning.
RECORD	Momentary push button, single-pole, double-throw switch used to activate external recording devices.
INDEX POSITIONING	Single lever control used to superimpose the positioning of the Read-Out index dot on the displaying waveform. This control incorporates backlash potentiometers to give vernier operation for accurate setting, which permits positioning the dots in the X and Y directions.
*External Horizontal Read Out Connector (J6800)	Cannon DPX 40-34S connector used to activate external recording devices. This connector includes connections to the RECORD push button switch.
*External Vertical Read Out Connector (J6900)	Cannon DPX 40-34S connector used to activate external recording devices. This connector includes connections to the horizontal and vertical Read-Out analog voltages.
*Located on top of instrument.	

section 2
operation

2-11. TRIGGERING HINTS

Table 2-4 includes some general hints on how to set up the Triggering Mode for a variety of triggering conditions.

TABLE 2-4
TRIGGERING HINTS

TRIGGERING CONDITIONS	TRIGGER MODE SETUP
Using Preset Positions	Set TRIG LEVEL and STABILITY controls to PRESET for initial setup
Using Internal Trigger Source on Read Out, Dual Trace, or other Time-Shared Displays	Always use the ACF Trigger Mode when displaying the Read-Out dots on internal triggering to avoid triggering distortion when positioning the Read Out. If the Read-Out dots blink on internal triggering, use External Trigger Source.
Signals Below 50 Cycles	Use DC Trigger Mode
Signals above 5 Megacycles	Use HF Trigger Mode and vary STABILITY control to obtain **lock-in**
Signals with Random Pulse Repetition Rates	If AC or ACF Trigger Mode cause jitter due to coupling time constants, use DC Trigger Mode
Signals with Base-Line Noise	Differentiate against the unwanted noise with the TRIG LEVEL control. When the signal is fast rise and the noise is of low frequency, then the ACF Trigger Mode may also be helpful.
Using Independent Displays	Internal triggering is difficult on Independent Displays. External Trigger Source is advised. Always adjust the sweep time of the Delaying Sweep to be longer than the time duration of the Main Sweep. If internal triggering is mandatory, the Main Sweep may be armed from the Delaying Sweep to assure a steady pattern. Adjust the DELAY MULTIPLIER for the most stable display.
Trouble Shooting with Single Channel or Dual Trace and Using Internal Trigger Source	Use AUTO SLOW Trigger Mode if signal is intermittent but above 50 cycles. Use AUTO FAST Trigger Mode when signals having pulse repetition frequencies over 2 Kc are to be viewed. AUTO Trigger Mode will show base line (for reference dc level or general oscilloscope operation) and will assure transfer from Channel to Channel in dual-trace operation even though the signal from either or both channels is temporarily removed.
Using Chopped Switch Mode	CHOPped Switch Mode should only be used to reduce visual flicker on long sweep time and low repetition time-shared displays. It may also be used to obtain Read Out on a slow Single Sweep. CHOPped Switch Mode transfers the Y electronic switch at a 100 Kc rate and the resultant transients make stable internal triggering difficult. External trigger source is always recommended when using CHOPped Switch Mode
Many Pulses per Sweep	If trigger pulses occur during certain sweep lock-out count points time, jitter of the display may become apparent. Judicious use of the STABILITY control will usually improve the synchronization. Do not let the sweep run recurrent if the signal is below 5 megacycles. This condition is often found when using the Delaying Sweep. The SWEEP LENGTH control will normally require only a slight readjustment without resetting the Delaying Sweep STABILITY control.
Very Low Level Trigger Signals	The longest trigger coupling time constant should be used to avoid further attenuation.
For Maximum Base Line On Fast Sweeps	AUTO SLOW Mode is recommended. Set the TRIG LEVEL control so that the Trigger Ready lamp is **just on** when trigger signal is removed. Set the trigger channel for maximum sensitivity (as above) and advance the STABILITY control to recurrent sweep operation. Then back off on STABILITY control until the sweep is "just triggered" when the sync signal is removed. Minimum trigger delay time is now assured.

SECTION III
APPLICATIONS

3-1. VERTICAL DEFLECTION CHANNEL

a. Dual-Trace Displays

The Du Mont Type 4202 Dual Trace Calibrated Preamplifier will enable you to obtain two separate traces on the screen. Detailed instructions for operating this unit in conjunction with the Type 425 Oscilloscope are given in a subsequent paragraph entitled "Accessory Functions."

b. Deflection Factor

The VOLTS/CM switch on the Y Preamplifier Plug-ins, control the vertical deflection factor in accurately calibrated steps. The VERNIER control, when pulled out, provides fine adjustment of the deflection factor. To make the deflection factor equal to that indicated by the VOLTS/CM switch, push in the VERNIER control and observe that the calibrator light is on.

A calibration check is readily available by setting the VOLTS/CM control to CAL and adjusting the GAIN CAL control to give a 4-centimeter pattern (vertical deflection) on the screen.

c. Applying a Signal to the Oscilloscope

Observe the following precautions when applying signals to the oscilloscope:

1. Avoid errors in readings due to stray coupling between circuits, particularly in the signal lead. As a rule, do not use long unshielded leads for applying signals to the oscilloscope. This fact holds for the audio-frequency spectrum, except possibly when making measurements on low-impedance circuits at very low frequencies. When shielded leads are used. the shields should be grounded to the oscilloscope chassis and to the chassis of the equipment being tested. For many applications, coaxial cables are recommended.
2. In broadband applications, it may be necessary to terminate a coaxial cable with a resistance equal to its characteristic impedance. This is done to prevent standing waves or ringing (high-freqency damped oscillations). As the length of the cable is increased, the necessity for proper termination becomes very important.

This termination is generally inserted at the oscilloscope end of the cable, although many signal sources may require an additional termination at the other end of the cable. Refer to the accessory section of your Du Mont catalog for a listing of cables, terminating resistors and pads.

3. To avoid erroneous results, the operator should simulate the actual operating conditions of the equipment being tested. For example, the equipment should work into a load impedance equal to that which it will see in actual use.
4. Consider the effect of loading upon the signal source due to the input impedance of the oscilloscope. The input impedance can be represented by a resistance shunted by a capacitance. The effective value of this resistance and capacitance is indicated on the front panel of the Y plug-in Unit. However, the operator should be aware that even with a few feet of cable in the input circuit, the loading capacitance on the circuit under investigation might be as high as 100 μμf or more.

   There are cases when connecting the input of the oscilloscope to a signal source, the effect of loading the source is not negligible. To minimize this loading, a probe may be used in the manner described in the paragraph entitled "Use of Probes."

d. Input Coupling

There are times when it is neither necessary nor desirable to display the dc component of the input waveform. A capacitor placed in series with the input connector will exclude the dc component while simultaneously permitting the ac component to be displayed. This is accomplished when the AC/DC switch on the Y Plug-in Unit is set to AC.

Care must be exercised when applying a fast rise, high-frequency signal to the input connector. It will be necessary to match and properly terminate the coaxial cable applying the signal to the oscilloscope. Compensated terminations with optimized VSWR are available as an accessory from Du Mont.

e. Use of Probes

An attenuator probe lessens both the capacitive and resistive loading caused by the oscilloscope to a minimum value. Simultaneously, while isolating the oscilloscope from the signal source, it reduces the effective sensitivity of the instrument. In other words, the displayed waveform will be reduced in amplitude by the attenuation factor of the probe. The attenuation introduced by the probe permits measurement of signal voltages in excess of those which may be accommodated by the Y Plug-in Unit.

When using a probe to sample signals from a tuned, matched, or otherwise critical circuit, capacitive loading may cause erroneous readings. In these cases it may be necessary to add capacity and resistance to the circuit under observation, of a value precisely equal to that of the probe impedance after the probe is removed. This substitution will equalize loading and restore the measured characteristics of the circuit under observation.

When using the attenuator probe to make amplitude measurements, multiply the observed amplitude of the display by the attenuation factor marked on the probe. The Du Mont Series of Y Plug-ins are provided with a slide switch which may be set to permit direct and accurate use of the read-out feature using a 10 to 1 attenuator probe.

The probe furnished with the Y Plug-in Units has an attenuator factor of 10 to 1. The maximum voltage that may be applied to the probe is 600 volts peak-to-peak. Voltages in excess of this value (either dc volts or peak ac volts) may cause damage to components inside of the probe housing.

IMPORTANT: Before using the probe, always check its adjustment.

An adjustable capacitor in the probe body compensates for variations in input capacitances from one Plug-in Unit to another. To insure accuracy in pulse and transient measurements, check the probe adjustment frequently. To check this adjustment, set the Main Sweep STABILITY control to RECurrent. Set the Main SWEEP RATE control to 500 us/cm. Apply the probe tip to the Main Sweep GATE OUT connector. Adjust the probe capacitor for a flat trace on the screen.

To preserve the waveform of the signal being displayed, clip the probe ground lead to the chassis of the equipment being tested. Select a short clean ground point near the probe input connection.

3-2. REDUCTION OF JITTER

Should the operator desire to display a waveform having either or both of the following characteristics:

1. The desired waveform has appreciable amplitude jitter; that is, there is present on the screen in addition to the desired waveform, a periodic waveform of lower frequency (amplitude modulation).

   NOTE: The ACF Trigger Mode may be used as a low-frequency reject filter if the applied signal contains frequency components high enough to go through this high-pass filter.
2. The frequency of the desired waveform jitters at a periodic rate lower than the frequency of the waveform under observation (frequency or pulse-time modulation).

If a source of the jitter signal alone is available (for example, if the jitter signal is the power-line waveform) you can decrease measurably, or often, almost eliminate the jitter in the display by the following techniques which employ controlled arming of the Delayed and Triggered Main Sweep.

1. On the Delaying Sweep Unit, apply the source of the jitter signal to the TRIG IN connector and set the TRIGGER SOURCE switch to EXT.

   NOTE: If the jitter signal is the power-line waveform, set the TRIGGER SOURCE switch to LINE.
2. On the Delaying Sweep Unit, set the TRIGGER MODE control to AC, the STABILITY and TRIG LEVEL controls to PRESET.
3. Turn the DELAY MULTIPLIER to 1.00 and the Delaying SWEEP RATE to 1 us.
4. Apply the desired signal in place of the jitter signal to the input of Channel A on the Y Plug-in Unit. Leave the jitter signal connected to the TRIG IN connector on the Delaying Sweep Unit.
5. Set the DISPLAY LOGIC switch to MAIN SWP and the Main TRIGGER MODE switch to ARMED AC or ARMED ACF.
6. Adjust the VOLTS/CM control on the Y Plug-in Unit and the Main SWEEP RATE control for an appropriate display of the pattern on the screen.
7. Set the Main TRIGGER SOURCE switch to INT. The resulting display should be comparatively jitter free.

3-3. VOLTAGE MEASUREMENTS

a. General

The Du Mont Type 425 Oscilloscope may be used to measure the voltage of the input signal by using the calibrated VOLTS/CM setting on the Y Plug-in Unit and observing the height of the display on the screen in centimeters.

When making voltage measurements, the operator should try to set up the instrument for full scale vertical deflection to insure maximum accuracy. Also, it is important to remember that the width of the trace may be an appreciable part of the overall measurement. This is particularly true when you are measuring signals of small amplitude or when stray signal pickup has broadened the trace. The operator should consistently make all measurements from one side of the trace. If the top side of the trace is used for one reading, it should be used for all succeeding readings.

b. How to Measure Peak-to-Peak Voltages Using the CRT Scale

The procedure employed for all voltage measurements is basically the same. The VERNIER control must be pushed in and the CAL lamp should be lit on the Y Plug-in Unit. The specific examples that follow are intended to show the general procedure. These examples may be adapted to fit any particular application.

To measure the ac component of the signal on display, set the AC/DC switch on the Y Plug-in Unit to AC. In this position, only the ac components of the input signal are displayed on the screen. However, when the ac component of the input is of very low frequency, set the AC/DC switch to DC to prevent errors. To make measurements, proceed as follows:

1. Using the calibrator scale, measure the vertical deflection in centimeters from the positive peak to the negative peak of the waveform. See Figure 3-1.

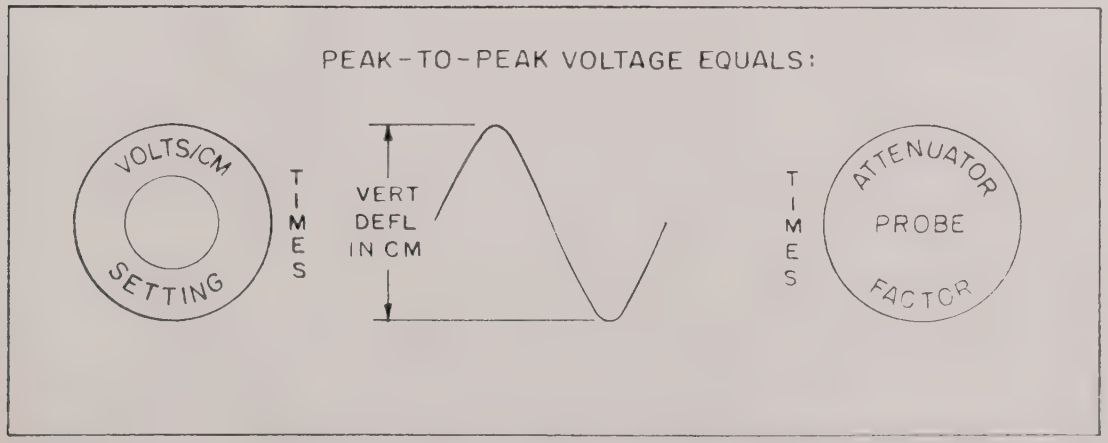


Figure 3-1. Peak-to-Peak Voltage Measurement

2. Multiply the vertical dimension obtained in Step 1 by the VOLTS/CM control setting on the Y Plug-in Unit to obtain the indicated voltage.
3. Multiply the indicated voltage obtained in Step 2 by the attenuation factor of the probe used to obtain the actual peak-to-peak voltage.

For example, suppose that you are using a 10:1 attenuator probe and the VOLTS/CM control is set to 0.1. Assume that the vertical distance between the peaks of the waveform measure 4 centimeters. Now, the vertical dimension of 4 centimeters is multiplied by the VOLTS/CM setting of 0.1 to give 0.4 volt. Next, multiply this result by 10, the attenuation ratio, of the probe. This gives 4 volts as the peak-to-peak voltage of the display waveform.

c. How to Measure Peak-to-Peak Voltages Using the Read-Out Switches

The procedure described in paragraph (b) requires scale intrepolation. The unique read-out feature of the Type 425 Oscilloscope permits us to obtain the peak-to-peak voltage directly from the Y Read-out area on the panel as follows: On the Main Frame, set DISPLAY LOGIC switch to R. O. and POLARITY switch to +. Set the READ OUT slide switch on the Y Plug-in Unit to PROBE X10 ATTEN, assuming use of a 10 to 1 probe.

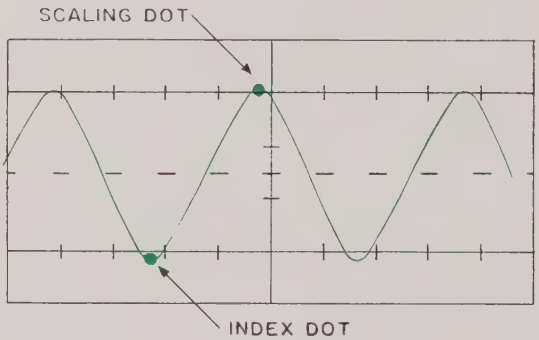


Figure 3-2a. Measuring Peak-to-Peak Voltages on the Positive Slope of the Display

With the INDEX POSITIONING control, position the index dot until it is superimposed on the waveform as shown in Figure 3-2a. Range the X and Y READ-OUT switches until the scaling dot is superimposed on the waveform as shown in Figure 3-2a. The user will have no trouble reading volts directly from the Y Read-Out area and without errors in scale parallax, interpolation, or multiplication.

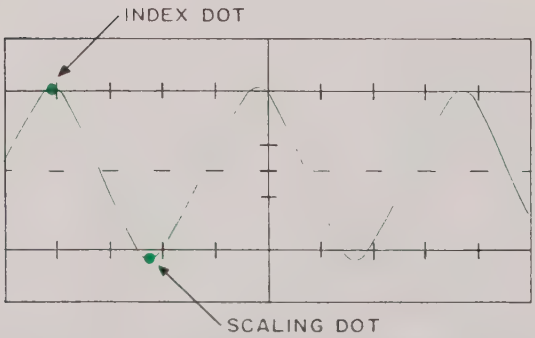


Figure 3-2b. Measuring Peak-to-Peak Voltages on the Negative Slope of the Display

If negative voltage readings are desired, set the Main Frame POLARITY switch to (—) and position the index and scaling dots to simulate Figure 3-2b. The user will automatically obtain the correct polarity and voltage from the Y Read-Out area.

d. How to Measure Instantaneous Voltages with Respect to Ground (or Some Other Reference Potential) Using the CRT Scale

The technique used for measuring instantaneous voltages with respect to a reference point, is virtually the same as that described for peak-to-peak voltage measurements. The difference is that now, a reference point must be established on the screen of the oscilloscope. Since voltage measurements with respect to ground are the most common, the procedure which follows, establishes a ground as the reference point. The same general technique may be used for instantaneous measurements with respect to any other potential, just so long as that potential is employed to establish the reference point.

To make measurements, proceed as follows:

1. On the Y Plug-in Unit, set the AC/DC switch to DC and push in the VERNIER control. The CAL lamp should be on.
2. Set the Main Frame STABILITY control to RECurrent.
3. To establish the reference point, touch the probe tip to the ground on the oscilloscope (or to the desired source potential, if a point other than ground is used). Vertically position the trace to a convenient point on the screen. This point should be chosen so that it lies on one of the major horizontal scale divisions. The chosen horizontal scale line, whcih is now coincident with the trace, is the reference line from which all voltage measurements are to be made.
4. Disconnect the probe tip from ground and connect it to the signal source without disturbing the PATTERN POSITIONING or Channel A POSITION controls.
5. Adjust the oscilloscope controls for a suitable and stable display.
6. Using the calibrator scale, measure the vertical deflection in centimeters from the desired point on the waveform to the pre-established reference line set up in step 3. See Figure 3-3.
7. Multiply the vertical dimension obtained in step 6 by the VOLTS/CM control setting on the Y Plug-in Unit to obtain the indicated voltage.
8. Multiply the indicated voltage obtained in step 7 by the attenuation factor of the probe used to obtain the actual instantaneous voltage.

For example, suppose that you are using a 10:1 attenuator probe and the VOLTS/CM control is set to 0.1. Assume that the vertical distance between desired point on the waveform to the pre-established reference line is 4 centimeters. Now, multiply this vertical deflection of 4 centimeters by the VOLTS/CM setting of 0.1 to give 0.4 volt. Next, multiply this result by 10, the attenuation factor of the probe. This shows that the instantaneous voltage with respect to ground to be 4 volts. Since the voltage point is above the reference line, the indicated polarity is positive.

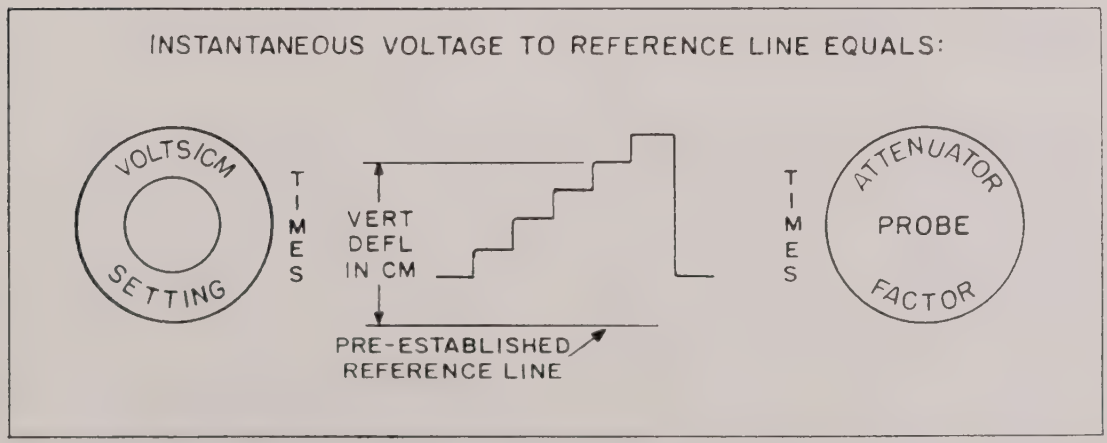


Figure 3-3. Instantaneous Voltage Measurement with Respect to Ground (or Some Other Reference Potential)

e. How to Measure Instantaneous Voltages with Respect to Ground Using the Read-Out Switches

Repeat steps 1 through 5 of the procedure described in paragraph (d). Assuming that you are using a 10 to 1 attenuator probe, set the DISPLAY LOGIC switch to R. O. and the READ-OUT slide switch on the Y Plug-in Unit to PROBE X10 ATTEN.

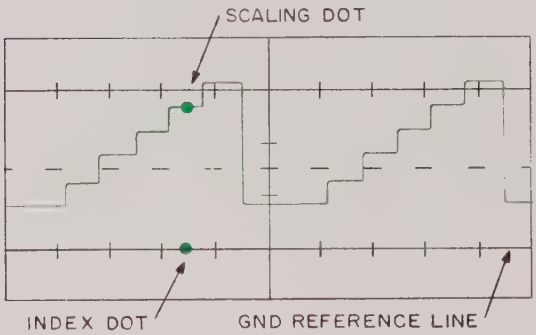


Figure 3-4a. Measuring Instantaneous Positive Voltages with Respect to Ground

Set Main Frame POLARITY switch to +. With the INDEX POSITIONING control, superimpose the index dot to the ground reference line. Range the Y Read-Out switches until the scaling dot is positioned to the desired point on the display. See Figure 3-4a. The instantaneous voltage is now read directly from the Y Read-Out area.

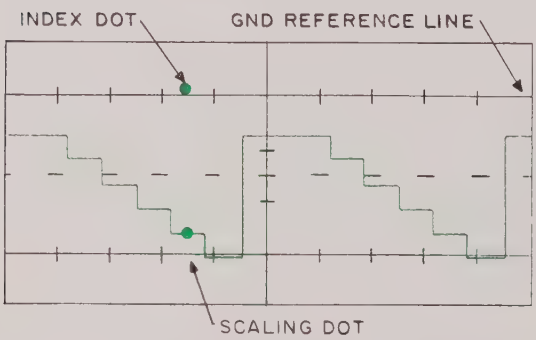


Figure 3-4b. Measuring Instantaneous Negative Voltages with Respect to Ground

For negative voltage readings, set the Main Frame POLARITY switch to (—) and position the index and scaling dots to simulate Figure 3-4b. The user will automatically obtain the correct polarity and voltage from the Y Read-Out area. It is apparent that use of the unique read-out feature makes voltage measurements a simple matter resulting in greater accuracy and superior restability.

3-4. HOW TO USE THE DIGITAL CONTACT CLOSURES FOR EXTERNAL READ-OUT INDICATION

A 40-pin connector is provided for each Read-Out axis and these two connectors are located on top of the Oscilloscope near the front panel. The Schematic entitled Horizontal and Vertical Read-Out Switches, Main Frame Module, indicates the coding of these connectors. The Du Mont Applications Group or your local Du Mont Sales Representative will be pleased to advise on the application of this Read-Out feature for integration into systems.

3-5. HOW TO USE THE EXTERNAL READ-OUT ANALOG OUTPUTS

Analog voltages of 99.9 millivolts maximum into an impedance of 100,000 ohms and proportional to the settings of the X and Y Read-Out switches, are available for each Read-Out axis. These outputs may be used with Pen recorders, X-Y plotters etc. The RECORD push button may be used to depress the stylus in X-Y plotter applications. The analog voltages may also be used to activate external go-no-go gauges and warning systems.

3-6. HOW TO COMMAND EXTERNAL EQUIPMENT TO RECORD

It is apparent that accessory external recording devices should not function while the operator positions the scaling Read-Out dot on the pattern. A RECORD push button is provided on the front panel of the oscilloscope to give a contact closure or opening when it is pushed. The RECORD push button may, therefore, be used to normally activate external recording equipment when the operator is satisfied with the positioning of the Read-Out dots.

3-7. MAKING RISE-TIME MEASUREMENTS (FIGURE 3-5)

Use of the Read-Out feature simplifies the normally used scale interpolation method and vastly improves the resetability and over-all accuracy of rise-time measurements. To measure rise time, set the Main Frame POLARITY switch to (+) and the DISPLAY LOGIC switch to R. O.

With the INDEX POSITIONING control, set the index dot on the lower flat portion of the waveform preceding the rise. Range the X and Y Read-Out switches until the scaling dot is positioned to the upper flat portion of the trace following the region of rise.

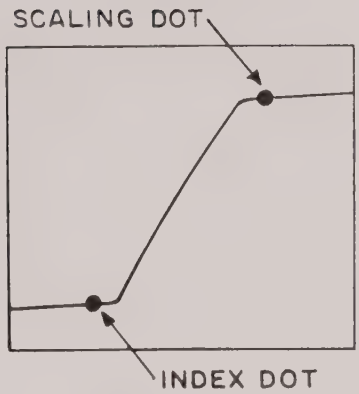


Figure 3-5a

Push in and hold the 10-90% button.

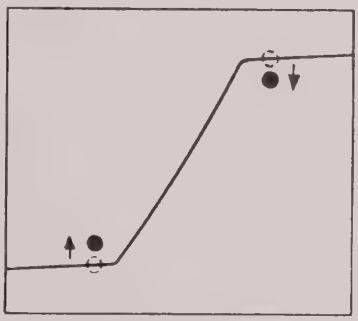


Figure 3-5b

Next, take the Main Sweep TRIG LEVEL control and phase (shift) the waveform to the right until it intersects the index dot.

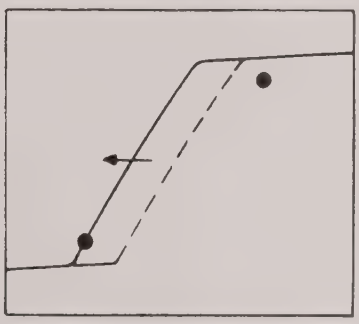


Figure 3-5c

Range the X Read-Out switch to move the scaling dot to the left until it intersects the waveform. The reading in the X Read-Out area is now an accurate and repeatable measure of rise time.

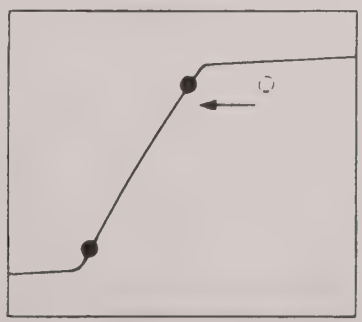


Figure 3-5d

3-8. MAKING FALL-TIME MEASUREMENTS (FIGURE 3-6)

To measure fall time, set the Main Frame POLARITY switch to (—) and the DISPLAY LOGIC switch to R. O.

With the INDEX POSITIONING control, set the index dot on the upper flat portion of the waveform preceding the fall. Range the X and Y Read-Out switches until the scaling dot is positioned to the lower flat portion of the trace following the region of fall.

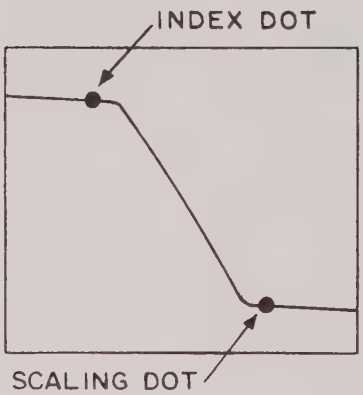


Figure 3-6a

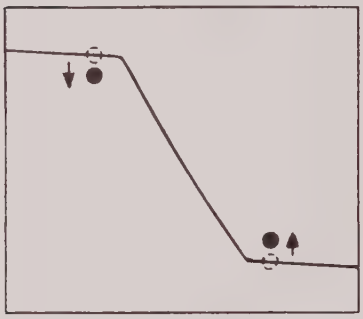


Figure 3-6b

Push in and hold the 10-90% button.

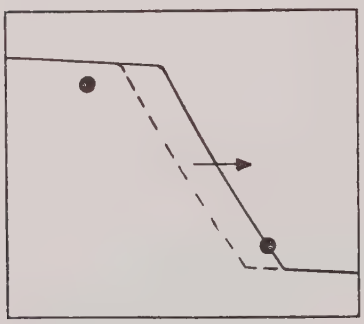


Figure 3-6c

Next, take the Main Sweep TRIG LEVEL control and phase (shift) the waveform to the right until it intersects the index dot.

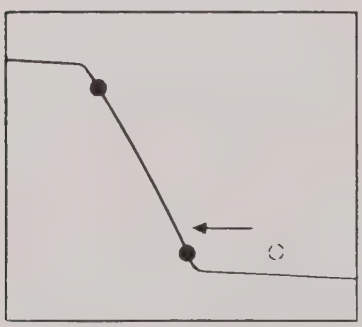


Figure 3-6d

Range the X Read-Out switch to move the scaling dot to the left until it intersects the waveform. The reading in the X Read-Out area is now an accurate and repeatable measure of fall time.

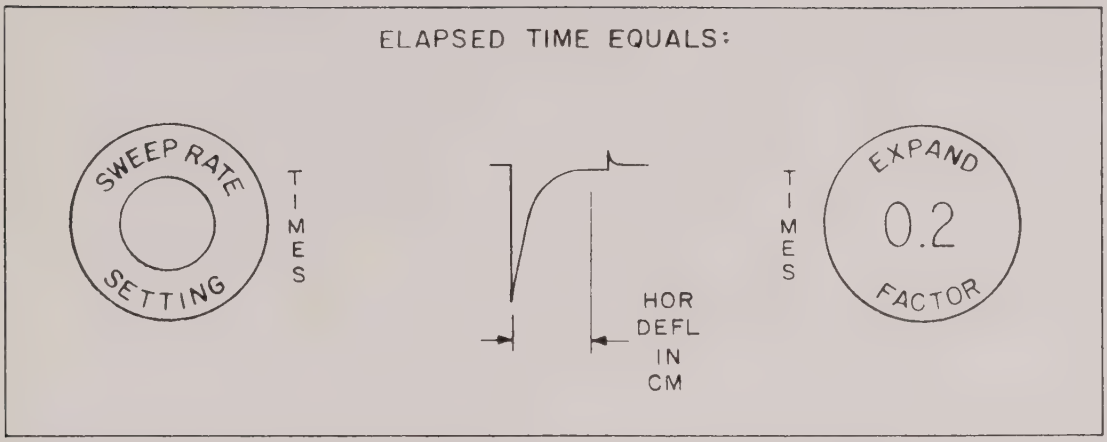


Figure 3-7. Measuring Elapsed Time When Expand Switch is Set to X5

3-9. TIME MEASUREMENTS

a. How to Make Elapsed Time Measurements Using the CRT Scale

Any horizontal distance on the screen of the oscilloscope can be used to represent a precise interval if time, when the time-base circuits are set up for calibrated sweep. Use of this feature permits you to accurately measure the elapsed time between the desired point of interest on the display. The Main Frame VERNIER control must be pushed in and the Main Sweep Rate dial lamp should be lit for these measurements. To measure the time interval, proceed as follows:

1. Set the EXPAND switch to X1.
2. Using the calibrator scale, measure the horizontal distance in centimeters between that portion of the display whose time interval you wish to find.
3. Multiply the horizontal dimension obtained in step 2 by the Main SWEEP RATE control setting to obtain the time interval.
4. If the EXPAND switch is set to X5, the reading obtained in step 3 must be multiplied by 0.2 to obtain the actual time interval. The Expander Indicator lamp will be off when the EXPAND switch is set to X5. This fact alerts the operator that the 0.2 factor must be applied to the SWEEP RATE control setting. See Figure 3-7.

b. How to Make Elapsed Time Measurements Using the Read-Out Switches

Using the Read-Out switches will permit you to obtain the elapsed time in seconds, milliseconds, or microseconds directly from the X-Read-Out area as follows: On the Main Frame. set DISPLAY LOGIC switch to R. O., POLARITY switch to (+), and EXPAND switch to X1. (If the EXPAND switch is set to X5, the 0.2 factor must be applied to the X Read-Out data.)

With the INDEX POSITIONING control, position the index dot to the first desired point on the waveform. Range the X and Y Read-Out switches until the scaling dot is positioned to the second desired point on the display. The elapsed time is now read directly from the X Read-Out area.

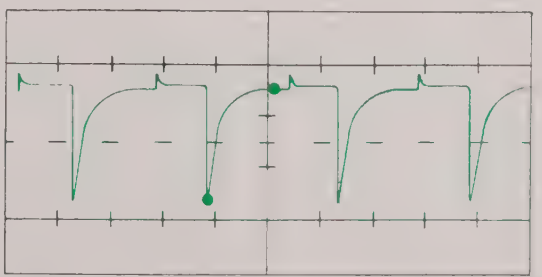


Figure 3-8a. Measuring Elapsed Time on the Positive Slope of the Display Using the Read-Out Switches

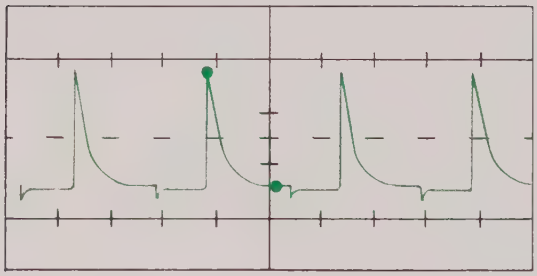


Figure 3-8b. Measuring Elapsed Time on the Negative Slope of the Display Using the Read-Out Switches

To measure the elapsed time for patterns with negative slopes, set the Main Frame POLARITY to (—). Position the index and scaling dots to the desired points on the display. The elapsed time in seconds, milliseconds, or microseconds, is read directly from the X Read-Out area.

c. How to Find Repetition Rate or Frequency Using the CRT Scale

The quantity called repetition rate or frequency for periodic signals can be expressed as the number of cycles or pulses per unit of time. To use the oscilloscope for measuring the frequency or repetition rate of periodic signals, proceed as follows:

1. Set the EXPAND switch to X1.
2. Using the calibrator scale, measure the horizontal distance in centimeters occupied by one cycle of the display under observation.
3. Multiply the horizontal dimension obtained in step 2 by the SWEEP RATE control setting.

   NOTE: If the EXPAND switch is set to X5, multiply the product obtained in step 3 by the factor 0.2.
4. Take the reciprocal of the product obtained in step 3 (that is, divide it into one). The resulting quotient is the desired frequency or repetition rate in cycles per second. See Figure 3-9.

d. How to Find Repetition Time and Frequency Using the X Read-Out Switches

Use of the Read-Out feature for finding the frequency of the display may be compared to the convenience of having your car equipped with automatic transmission as opposed to the manual shift. The task of finding the frequency is now reduced to that of simply taking the reciprocal of the X Read-Out data. See Figure 3-10.

When using the Horizontal Read-Out switches, the Read-Out information will be accurately indicated regardless of the EXPAND switch setting. The Read-Out dots and the signal are expanded together when the EXPAND switch is set to X5.

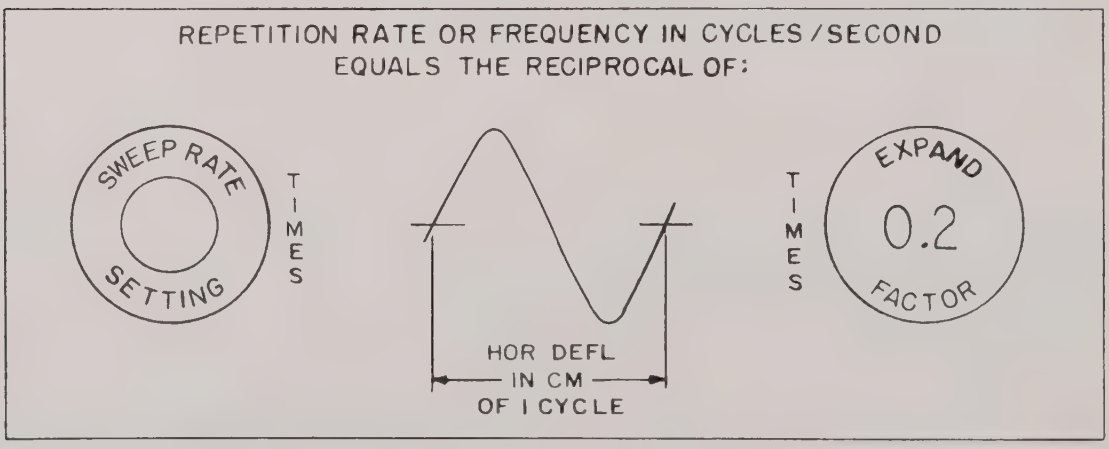


Figure 3-9. Finding the Frequency When Expand Switch is Set to X5

Set the DISPLAY LOGIC switch to R. O. Adjust the INDEX POSITIONING control until the index dot is superimposed on the desired point of the waveform. Range the X Read-Out switches until the scaling dot has moved over to the next corresponding point on the waveform. Take the reciprocal of the X Read-Out information to obtain the repetition rate or frequency.

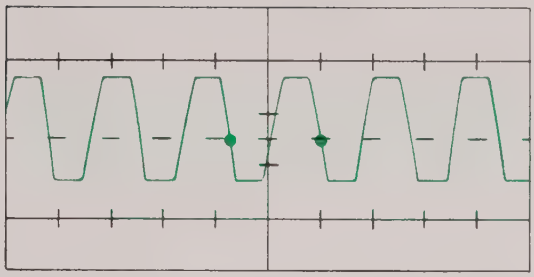


Figure 3-10a. Finding the Frequency Using the Read-Out Feature. Expand Switch is Set to X1

Set EXPAND switch to X5. Expansion improves the precision of alignment between the dot and the pattern and results in greater Read-Out accuracy. Taking the reciprocal of the X Read-Out data will yield the frequency.

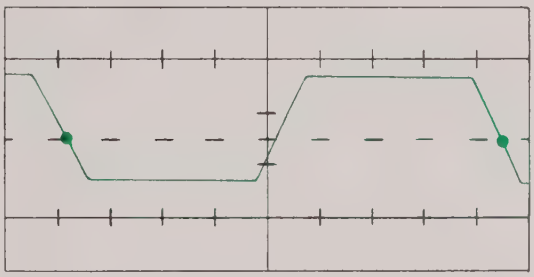


Figure 3-10b. Finding the Frequency Using the Read-Out Feature. Expand Switch is Set to X5

3-10. PHASE ANGLE MEASUREMENTS

This operation is useful in determining the phase displacement between two identical waveforms of the same frequency; for example, two sine waves. The useful frequency range is from a few cycles to about 10 megacycles. For frequency over 2 megacycles, the effective resolution of the readings is reduced by a factor of approximately 5. To take phase angle measurement, proceed as follows:

1. Set the controls as indicated in Table 3-1.
2. Connect the source of the reference waveform to the Channel A input connector on the Y Dual-Trace Plug-in, and to the Main Frame EXT SYNC connector.
3. Set the Main SWEEP RATE control so that the display includes several cycles of the input signal.
4. Using the Channel A POSITION control, keep the trace centered vertically while adjusting Channel A VOLTS/CM and VERNIER controls so that the peak-to-peak vertical deflection caused by the reference signal is precisely 5 centimeters.
5. Keeping the display centered vertically, adjust the Main Sweep TRIG LEVEL control so that

TABLE 3-1
PHASE ANGLE MEASUREMENT SETUP

CONTROL	SETTING
MAIN FRAME	
DISPLAY LOGIC	MAIN SWP
EXPAND	X1 (For signals over 2 mc, set to X5)
TRIGGER MODE	NORMAL AC OR ACF
STABILITY	PRESET
TRIGGER SOURCE	+ EXT
TRIG LEVEL	PRESET
DELAYING SWEEP PLUG-IN	
PICK-OFF SOURCE	MAIN SWP
Y DUAL TRACE PLUG-IN	
INPUT SELECTOR	A
AC/DC	Both AC or both DC
POLARITY	Both NORMAL or both INVERTED

the start (left-hand end) of the displayed waveform appears precisely at one of the horizontal lines of the scale.

6. With the PATTERN POSITIONING control, position the left-hand end of the waveform precisely to the left-hand vertical scale line.
7. Set the Main SWEEP RATE and VERNIER controls so that precisely 1 cycle of the waveform is displayed over the 10-centimeter scale length. In succeeding steps, do not retouch the Main Sweep or Channel A controls.
8. Apply the second waveform, the waveform whose phase is to be compared, to the Channel B input connector on the Y Dual-Trace Plug-in.
9. Set the INPUT SELECTOR switch to B. You should now see a stable display of the second waveform.
10. Using the Channel B POSITION control, keep the trace centered vertically while adjusting the Channel B VOLTS/CM and VERNIER controls so that the peak-to-peak vertical deflection caused by the second input signal is precisely 5 centimeters.
11. Turn the INPUT SELECTOR switch to A & B. You should now see a stable display that includes both the reference waveform and the second waveform whose phase relationship you want to measure with respect to the reference waveform.
12. Remove the right hand dust cover of the oscilloscope. Locate the Z INPUT jumper-plug on the high-voltage supply module (P1003). Disconnect the jumper-plug from the Z INPUT connector. Then:
    a. If the Main Sweep rate is faster than about 10 microseconds per centimeter, connect a test lead from the Z INPUT connector to the DEL TRIG BNC connector on the Delaying Sweep Plug-in Unit;

    OR

    b. If the Main Sweep rate is slower than about 10 microseconds per centimeter, connect a test lead from the Z INPUT connector to the GATE BNC connector on the Delaying Sweep Plug-in Unit. On this same Plug-in, connect a lead between the DEL TRIG and the TRIG IN BNC connectors.
13. Set the Delaying TRIGGER SOURCE switch to + EXT.
14. Turn the Delaying SWEEP RATE control for a delaying sweep rate about ten times as fast as the Main Sweep rate. If the Main Sweep rate is so fast as to prevent such a setting, set the Delaying SWEEP RATE control to 1 microsecond per centimeter.
15. Set the Delaying TRIG LEVEL and STABILITY controls to PRESET.
16. Turn the INTENSITY control slowly to the left until the trace just disappears. Then, turn the INTENSITY control slowly to the right until the trace reappears. Portions of each of the displayed waveforms should now be blanked-out and you should be able to position this blanked-out portion horizontally by means of the DELAY MULTIPLIER control. This blanked-out portion appears at a distance from the left-hand end of the display corresponding to the setting of the DELAY MULTIPLIER control.
17. Position the start (left-hand end) of the blanked-out portion of the display precisely to the point where the reference waveform crosses the horizontal line of the scale and record the setting of the DELAY MULTIPLIER control.
18. Position the start of the blanked-out portion of the display precisely to the point where the *other* waveform crosses the same horizontal scale line and record the new setting of the DELAY MULTIPLIER control.
19. The phase difference between the two displayed waveforms is now determined as follows:
    a. If the EXPAND switch was set to X1 during the preceding operations, multiply the difference between the two DELAY MULTIPLIER settings by 36°.
    b. If the EXPAND switch was set to X5 during the preceding operations (for frequencies between 2 and 10 megacycles), multiply the difference between the two DELAY MULTIPLIER settings by 180°. The result, in either case, is the phase difference between the two displayed waveforms.
20. Always reconnect the jumper-plug to the Z INPUT connector after completing phase measurements. This maintains the brightening gate characteristics for fast sweep rates.

3-11. ACCESSORY FUNCTIONS

a. Independent Displays (Time-Shared, Dual-Beam 4-Channel Operation)

When a Type 4202 Dual-Trace Y Preamplifier and a Type 4203 Delaying Sweep Plug-in Unit are used within the Main Frame of the oscilloscope, it becomes possible to view two unrelated input signals against two unrelated time bases. This is accomplished by use of the electronic switches which are available in each axis within the Main Frame of the oscilloscope. The Delaying Sweep is used with the Channel B input and the Main Sweep is used with Channel A input of the Dual-Trace Plug-in Unit.

Since time-sharing is synchronized with the Delay-

ing Sweep, it becomes necessary for this sweep to be always longer in time (having slower sweep rate at 10 cm display) than the Main Sweep. Time-sharing the display may cause aberrations in the Channel A vertical display. To minimize these distortions, it is recommended that the Main Sweep be set up as a Delayed Main Sweep, armed at some point as soon as possible after the start of the Delaying Sweep.

1. To set up the independent displays, set the DISPLAY LOGIC switch to MAIN SWP and the INPUT SELECTOR switch to A. Adjust the instrument for a normal display.
2. Set the DISPLAY LOGIC switch to DELAYING SWP, the INPUT SELECTOR to B, and observe the display.
3. On the Main Frame, set the DISPLAY LOGIC switch to INDEP DISPLAY and TRIGGER MODE to ARMED AC or ACF (depending on the signal). Set the DELAY MULTIPLIER to 0.09 and the PICK-OFF SOURCE switch to DEL SWP.
4. Set the Delaying SWEEP RATE control for a slower rate than the Main SWEEP RATE control setting. A stable pattern should now appear on the screen.

Instabilities may exist when the TRIGGER SOURCE switch is set to INT and AC or DC TRIGGER MODE settings are used, or when the SWITCH MODE push button is set to CHOP. Much difficulty can be avoided if the TRIGGER SOURCE switch is set to EXT when using the independent display operation.

b. Calibrator

An internal precision 60-cycle calibrator signal is available for normalizing the sensitivity of the Y Amplifier system and for checking the sweep rate accuracy in locations where a stable and known-line frequency exists. The calibrator trapezoidal waveform is applied to the Y Amplifier when the VOLTS/CM switch is set to CAL. A pin jack is provided on all Y Plug-in Units for checking out the 10 to 1 attenuator probe.

To check the attenuator probe calibration, proceed as follows:

Set the VOLTS/CM to 0.05 and apply the probe tip to the CAL 2V pin jack. The amplitude of the calibrator signal should be 4 centimeters; if not, adjust the GAIN CAL screwdriver control for 4 centimeters of vertical deflection.

c. Intensity (Z-Axis) Modulation

Input for intensity modulation of the trace may be connected to the Z INPUT connector (J1003) located on the high-voltage module. To accomplish this, remove the right-hand dust cover of the oscilloscope. Locate the Z Input jumper-plug and disconnect it. Connect the intensity modulation signal to the Z INPUT connector which applies the signal between CRT cathode and ground. A positive signal of 20 volts will cause sufficient blanking. The coupling time constants is approximately 15 milliseconds with an input impedance of approximately 15,000 ohms.

Always reconnect the jumper-plug to the Z INPUT connector when not using the external intensity modulation feature. This maintains the initial part of the trace at its normal brightness on fast sweeps.

d. Scale Illumination

The scale dimmer control, labeled SCALE may be adjusted to suit the ambient lighting conditions of the room. It is recommended that the scale be used only as an accessory when Read-Out is available; the scale should be removed when taking photographs of fast, low-repetition transients. A light-filter (green for P2, blue for P11, and amber for P7) is supplied and used to increase trace contrast. Normally, this filter should be mounted next to the cathode-ray tube screen so that it does not block light from the calibrating scale lines.

e. Photographic Recording

Permanent photographic records of waveforms with or without the superposition of the illuminated scale, are readily obtainable. Since the scale illumination level is adjustable from the front panel, the pattern under observation and scale can generally be photographed simultaneously.

For detailed information on photographic recording of waveforms, the operator is referred to a booklet titled "Techniques of Photo-recording from Cathode-ray Tubes," published by the Industrial Electronics Division of Allen B. Du Mont Laboratories, Inc. See the Du Mont catalog for a complete line of photographic equipment for this purpose.

f. Direct Connection to CRT Deflection Plates

An accessory is available from the Allen B. Du Mont Laboratories, to replace the vertical delay line and permit direct control for VSWR input to the vertical deflection plates. AC coupling permits use of the positioning voltages and astigmatism controls provided within the oscilloscope. Instructions with this accessory will detail its use for direct access to the horizontal and vertical deflection plates of the cathode-ray tube.

DU MONT
INSTRUMENT WARRANTY AND SERVICE NOTICE

WARRANTY

Allen B. Du Mont Laboratories, Inc. warrants that each new Cathode-ray Oscilloscope, Automotive Test Equipment, and other Electronic or Electrical Test or Measuring Equipment (hereinafter referred to as "Instrument") manufactured or sold by it, is free from defects in material or workmanship under normal use and service for a period of one year from the date of its sale to the first purchaser for use. If, upon examination by Du Mont, the Instrument is determined to be defective in workmanship or material, Du Mont will, subject to the conditions set forth below, either repair the defective part or replace it with a new part. Du Mont shall not be liable for any delay or failure to furnish a replacement part resulting directly or indirectly from any governmental restriction, priority or allocation or any other governmental regulatory order or action, nor shall Du Mont be liable for damages by reason of the failure of the Instrument to perform properly or for any consequential damages. This warranty does not apply to any Instrument that has been subject to negligence, accident, misuse or improper installation or operation or that in any way has been tampered with, altered or repaired by any person other than an authorized Du Mont service organization or an employee thereof, or to any Instrument whose serial number has been altered, defaced or removed, or to any Instrument purchased within, and thereafter removed beyond, the continental limits of the United States.

This warranty shall, at Du Mont's option, become void unless registration thereof is promptly effected as provided below. This warranty is in lieu of all other warranties, expressed or implied, and no one is authorized to assume any liability on behalf of Du Mont or impose any obligation upon it in connection with the sale of any Instrument, other than as stated above.

REGISTERING THE WARRANTY

To register this warranty, the enclosed warranty registration card must be properly filled out and mailed to the Instrument Service Department immediately upon receipt of the equipment. Complete information is necessary. BOTH THE TYPE NUMBER AND THE SERIAL NUMBER OF THE INSTRUMENT MUST BE GIVEN ON THIS CARD. Instruments must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time and to furnish merchandise in accordance with current specifications without incurring any liability to modify equipment previously sold, or to supply new equipment in accordance with earlier specifications excepting under the classification of special apparatus.

SERVICE

In order to insure service under our warranty, the enclosed warranty service card must be properly filled out and returned to the factory. In all cases where service or adjustment is requested, please first contact the factory or authorized depot, giving complete information concerning the nature of the failure and describing the manner in which the equipment was used when failure occurred. THE TYPE NUMBER AND SERIAL NUMBER of the equipment must also be given. In this way, much time can be saved and unnecessary inconvenience often avoided. When writing to the factory in this respect, address:

ALLEN B. DU MONT LABORATORIES, INC.
Instrument Service Department
Industrial Electronics Division
750 Bloomfield Avenue, Clifton, New Jersey

The Instrument Service Department will then send to the customer the written procedure for disposition and shipping instructions. All equipment should be packed and shipped in accordance with this procedure; and identification tags should be attached to each tube or instrument.

REPLACEMENT PARTS

If it is necessary to order a replacement component from the factory, always give the Type number and Serial number of the Instrument. Before ordering parts for in-warranty replacement or purchasing them for out-of-warranty replacement, be sure to consult the Parts List in the Instruction Manual. The Parts List gives the values, tolerances, ratings, and Du Mont part number for all electrical components used in the Instruments. This will help to expedite service.

ALLEN B. DU MONT LABORATORIES, INC.

Industrial Electronics Division

750 Bloomfield Avenue., Clifton, New Jersey

PATENT NOTICE

Manufactured under one or more U. S. Patents owned or controlled by Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Avenue, Clifton, New Jersey, U.S.A. Patent Numbers supplied upon request.